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HONOLULU

1924

The Makaweli overhead system was laid out in an old ratoon field near the manager's house and the government road. The standpipes were 25 feet high, guyed with 3 stay-wires. They were set 80 feet apart, but Manager Baldwin says that 60 feet would be a better distance. The nozzles used finally, after trying many, were the geared type, costing about $14 apiece. This would take about 8 per acre, a rather expensive item. The field being laid out previously in the old style, there could be no cultivation by animals, which is one of the chief advantages to the system. The field raised good cane, and would be continued with the overhead system except that it is too old a ratoon field and must be plowed. Another small layout was made some little time ago on a dry pali nearby.

John Hind at Hawi has tried overhead irrigation for several years on a small plot. This year he has gone past the experimental stage, and already a field of 100 acres is in, with another of 88 acres to be planted as soon as the balance of the pipe arrives. Next year, possibly, another 250 acres will be planted to it. One has only to look at the system working and compare the fields laid out under the old style with that of the new, to see how well it fits Hawi's conditions. The writer sees places where it may possibly work to advantage, but one knows that it would be too expensive a proposition for some, and not adapted for others. But Hawi has a porous soil, a shortage of water, and at many times, a labor shortage.

To illustrate how the system is laid out suppose we take an even field with gentle slope, the greater the slope the better the "head" of course.

First we have our main line running with the slope. We will have to go back to get enough "head" or pressure, or as Hawi is doing on its new field, put in a pump to give us enough pressure, say 40 lbs. per sq. in. A pressure gauge helps us determine this practically. From our main line of say 6″ pipe, we run off laterals to right and to the left every 56 feet. If we plant our cane 4 feet wide, we have 14 lines of cane between our laterals. On our laterals we place our standpipes vertically, every 60 feet. The height of these standpipes varies for locality, Hawi's cane being short and the wind favorable, 10 feet is the height of the pipe used there. Our laterals should not be much over 400 feet long. They should come off at right angles, for a perpendicular would be a shorter line than a diagonal. The reason we take 60 feet is because the 20-foot lengths of pipe do not have to be cut.

We reduce our main line as our pressure becomes greater, and as our friction increases. The laterals will probably start at 1½″ in diameter, reduced to 1¼″ to 1″ to ¾″. The standpipes are ¾″ reduced to ⅜″. The sizes of our pipes vary according to our conditions, depending on the amount of water we want to give in a certain time.

The sprinklers used at Hawi are made in the shop, costing 45 cents apiece. They are in two parts and the upper portion can be lifted off by the use of a stick in big cane and the pressure will blow out small cloggings. Hawi screens all the water entering. The layout for each field differs. A contour map gives one the necessary data, and the system can be figured out in the office as to what pipes are necessary, etc.

Without going into further details of the system, the following advantages and disadvantages may be considered.

Advantages of Overhead System

(1) *Water Regulation:* Any amount of water may be given, 1 inch or 5 inches, largely depending upon the time applied.

(2) *Water Saving:* Hawi expects a saving in water. "Old" style 1,300,000 gallons per day for 100-acre field; "overhead" only 750,000 gallons, but no actual data from measurements. Paia's sprinkler system took less water. No seepage from ditches, but more evaporation.

(3) *Cultivation:* Cheap cultivation. Unirrigated conditions. Very little hand hoeing.

(4) *Mulch Control of Moisture:* After irrigation, cultivation can give mulch, at same time get small grass.

(5) *Water Immediately After Harvesting:* This is a most important consideration, and a reason why such sensitive canes as H 109 have failed to ratoon well on some places.

(6) *Labor Saving in Cultivation and in Irrigation:* The Paia system showed no labor saving, but it was on a two-acre piece. The man at Hawi hoes nearly all day long. At Hawi, one round is made on the 100-acre field in 7 days, or 14 men total, one day and one night man. Under the old system at least 120 men would have been needed.

(7) *Fire Protection:* Very apparent.

(8) *Hoeing:* Less weeds through animal cultivation. Less weeds from dirty ditches, etc.

(9) *Area Saved:* Saving in acres taken up by ditches, water courses, etc.

(10) *Harvesting:* Simplified by straight lines.

(11) *Day and Night Irrigation.*

(12) *Fertilizer Action:* Not delayed by lack of proper moisture.

Disadvantages

(1) The cost, $150 to $200 per acre, depending on individual layouts.

(2) Sprinklers may not start well. Some may clog later from accumulation.

(3) Evaporation loss, and loss through some water not getting to root through trash and heavy cane, compensated somewhat by less ditch seepage losses.

A study of soil moisture and growth measurements of both the overhead system and the old contour layouts will be a most interesting one, and next year, we should have more to report. The overhead system is one of the most interesting developments in irrigation for some time, for it offers possibilities for certain plantations short of water, and having a very porous condition of soil.

Orchard System

One small area has been harvested at Ewa, but a further trial is desired before discussion.

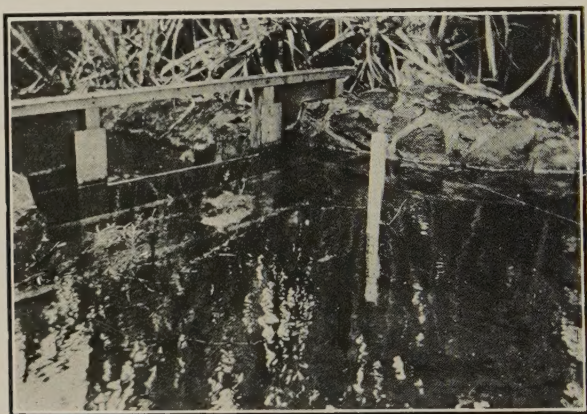
Kilauea harvested its first areas. Figures are not available, and should not be used for comparison as the original area was not a fair test with the rest of the field, the balance of the field having mud press, and the "long line" area none. The writer visited this area, now on first ratoons, about a month ago, and it was ratooning fully twice as well as the rest of the field, as irrigation water could be

given quickly and cheaply immediately after harvesting, weeds being kept in check by cultivation, etc., while the rest of the field simply could not be cared for by the contour system, due to labor and water shortage.

Koloa should harvest a very comparable area of about 25 acres each on the orchard system and contour system next year.

The system seems admirably adapted to semi-irrigated conditions, where cultivation is possible and an insurance given for a quick irrigation when water is available.

Last August, Oahu Sugar Company put in a nine-acre test of the "Orchard" system against the "Peru" system, against 32 feet and 40 feet water courses of the older systems. Manager Thomson of Oahu Sugar Company very kindly supplies the following data. When the area is harvested next year, very valuable data may be obtained. The actual water going on each system was measured by use of a rectangular weir.



The Orchard system of 9.02 acres, averaged for 10 irrigations, 140, 195 gallons per acre per irrigation, or 5.2 acre inches.

The Peru system or units of 4 long lines as in the Orchard system, of 2.98 acres, averages 225, 150 gallons per acre per irrigation for 9 irrigations, or 8.2-acre inches.

The 32-foot wide watercourse requires the least amount of water on a 6.38-acre piece, averaging 81,705 gallons per acre per irrigation, or 3.0-acre inches.

The 40-foot watercourse on a 3.08-acre piece averages for 11 irrigations, 90,780 gallons per acre per irrigation, or 3.3-acre inches.

The cane in the old style is planted 5 feet apart, in the Peru and Orchard systems 4¼ feet apart. There appears to be more sticks in the Orchard system though smaller in diameter. No area is taken up by water courses. The Peru system has more area taken up by level ditches.

To date then, with cane one year old, the narrower water course on the old contour system, one line irrigated at a time, requires much less water. More area is devoted to water courses per acre. However, the final test comes at harvesting next year, when the sugar per unit of gallons of water used is figured. It is too soon to draw conclusions, aside from the fact that the Orchard system for Waipahu conditions is requiring more water than was anticipated.

Orchard System at Makaweli

This area planted for the 1923 crop by Manager B. D. Baldwin, consisting of some 5 acres, was harvested recently and Manager Baldwin states that the "long" line area yielded 7.7 tons sugar per acre, that the "old" style went 7.3 tons sugar per acre for the rest of the field. Here the slope was average, the soil red loam towards silt, and not the porous soil giving lateral percolations at Kilauea. The area at first was irrigated once in ten days, but as the cane became more mature, it required more irrigation. Finally, it required a daily irrigation, but Manager Baldwin believes with a total amount not in excess of the 14-day period which the rest of the field was getting. No actual water measurements were obtained. The ratoons are now up two feet, of excellent stand. They will be irrigated twice a week consistently. The system yielded much better than was expected.

The optimum distance between level ditches on the Orchard system is between 250 and 300 feet.

Baldwin Flume System

At the time of the writer's visit at the beginning of the year, the field of about 30 acres in the Baldwin flume system had just been harvested. Then Acting Manager Nicoll told us that the yield was not very satisfactory. Looking at the field one should not blame the system entirely for it is a rather uneven field for a test. A field of some 50 acres for the 1924 crop will give good data next year. No more new areas are being laid out.

Waipio System

The Waipio system of cutting lines, described in the annual report for 1922 of the Irrigation and Fertilization Committee of the Hawaiian Sugar Planters' Association, is about 18 acres in extent at Waipio. A year's trial shows that it is not adapted for the level areas, requiring much more water. The advantage gained is in the doing away with the washing on the palis. Heavy paper about 2 feet square in size is placed on the bottom of the cuts. This keeps the cuts at an even level.

Ditches

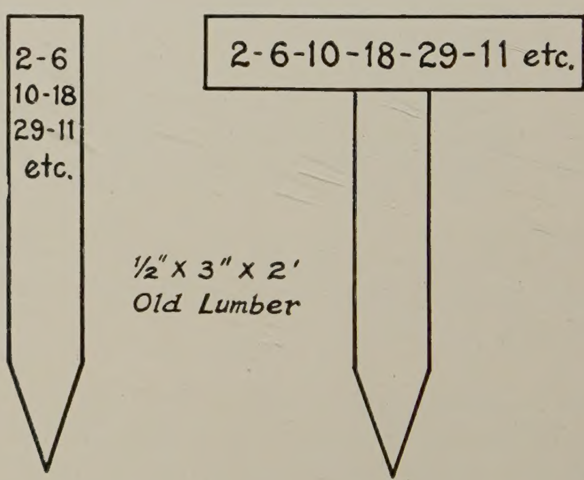
Several large ditch projects were underway this year. Kilauea completed a ditch bringing some 10 million gallons a day from the Kalihiwai side. It required a large amount of tunneling and a long syphon, all work being done by the plantation. Lihue started a huge project of tunneling the mountains to Hanalei, that this water may supply more water to Lihue and Koloa. Paia and Puunene are still doing considerable big ditch work. Koloa completed a long ditch of two miles with concrete lining that will save a large seepage loss. Pioneer is improving its ditches by concrete lining. Oahu Sugar Company is using blue lava stone slabs 1′x1′x4″ for lining ditches filling the cracks with cement, and putting in a 3 to 4-inch concrete bottom. This type ditch can be constructed for a little over $2 a foot for a 3½ foot wide ditch, where rock is available. Objections have been raised that water leaks through the cracks between the stones and gets behind the wall. But with this type, individual blocks can be taken out when cracked and the ditch quickly repaired.

As to field level ditches, the tendency in the Islands at the present time is to put the ditches closer together. Manager Thomson of Oahu Sugar Company reports that 40 to 45 lines of cane is the optimum distance between ditches. The ditches are being shortened too, meaning more straight ditches, of course.

Ewa has field tests installed with 20, 30, 40 to 60 lines per level ditch which will give them valuable data.

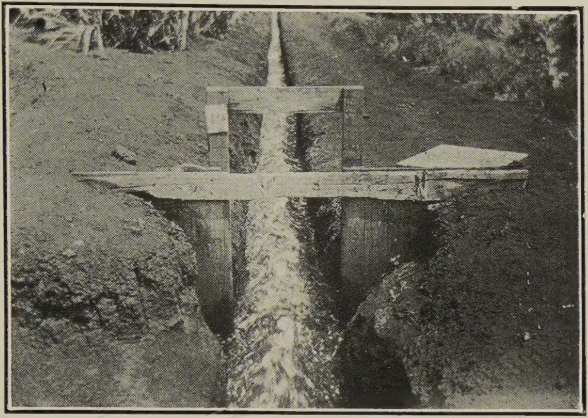
Method of Marking Irrigation

Many of the plantations use a "lepo" or earth pani at the head of the level ditch to mark the day of the irrigation. The use of a stake for this purpose instead, is not new in application, but is a practical means of getting closer supervision. It is the writer's opinion that the poor stand in many H 109 fields using body seed, is due to a failure of the water lunas to properly get their second and third waters on time. One plantation on this island figures that the second water can be delayed as much as ten days, with good results, but the writer advocates prompt attention and observations for the first irrigations to insure a good stand. The amount of water need not be great, but the seed must not dry out. Koloa this year uses a stake at each level ditch especially in the plant field, marked thus:



The ditchman has a blue lumber crayon and marks the date of the irrigation each time the ditch is completed (or started). Thus an exact record is had of the irrigation for at least 10 irrigations instead of one or two soil markers. The overseers and manager riding around, on seeing some dry or yellow ditch can tell right away the history of the field as far as water is concerned and there is thus no trusting to memory or scratch pads for the water, for days come around faster than one imagines on irrigation work.

Hawi has a number on each level ditch gate as:



A report of each operation for the level ditch is made by the water or section luna, and kept in his note book and a copy sent to the office. Days of month in one column, number of level ditch in other, with symbols as "I" for irrigation, "H" for hoeing, "F" for fertilizing, etc. Possibly other places have other ways of keeping tab on the irrigation, but no matter how it is done, the essential is to give the plant cane a good stand. Replanting is an expensive item.

Trash Panis

Koloa now uses the "Maui" style of trash pani, introduced on Kauai by Manager Caleb Burns. On the palis especially, instead of a flimsy small trash pani that washes out on second water, this pani is in "for keeps". Many plantations could improve on the type of pani used. It costs but little more to put a good one in like the Maui pani, and it is cheaper, for it stays.

Water Measurement

The Sugar Planters' Experiment Station is making a detailed study of measuring devices. One will note in travelling to the various plantations, the increased use of weirs for measuring water. The rectangular weir is more commonly used. At Ewa, Hawi and several other plantations, the Gurley self-recording meter is in use, giving an exact record of the flow. A type of less expensive meter of the orifice type when recently tested out, checked out within a very close amount of a weir measurement. This records in acre feet. Shortly the Station will be able to say under what condition it may be used to advantage, but further testing is in order. The value of the cheaper instruments lies in our knowing the exact amount of water entering each field, and not figuring by our pumps, for seepage losses vary also.

Waimanalo is measuring water going on to many of the fields. With the new method of *growth measurement,* valuable records of what are happening to our fields may be recorded, and a correlation made between the amount of water, soil temperature, growth, fertilizer action, etc.

Concrete Gates

Many plantations have put in concrete gates on straight and level ditches. Head Luna Eby of McBryde has applied for a patent on a portable concrete gate. The essential features are a reinforcing with pig-wire netting, a two-inch thickness of the slab, light and portable, and an iron slide door. The use of lumber for water gates runs into huge sums on the bigger plantations, and these inexpensive concrete gates will not burn out from cane fires. The objection raised is that they may chip. They are easily replaced. The cost is estimated at $2.50 apiece without the iron door.

W. P. Alexander's Bulletin

One of the biggest additions to the irrigation work in Hawaii for the year is W. P. Alexander's Bulletin on "Irrigation of Sugar Cane in Hawaii," wherein is recorded for reference all the irrigation data published up to this year.

Irrigation Observations

The writer has observed during the year the following tendencies:

(1) Shorter level ditches, and fewer lines of cane in a level ditch, where water is a problem. Say an optimum of 40 to 45 lines of 5 feet in width.

(2) Where there is a water shortage, the old style of "one-line-one-line" is considered the best method.

(3) Lines are shorter. 30 to 35-foot water courses more in vogue.

(4) The importance of getting water on the ratoons immediately, especially with H 109 cane, to insure a good stand on the ratoon.

(5) A tendency on many places to leave wide watercourse pathways, that is, not heading out the lines properly. The new Moler-Oleson planting machine will insure well-headed-out lines. Some plantations always place two seeds at the water course, and this we believe a good practice.

(6) More and more electric pumps are being installed, large and small.

(7) The semi-diesel engines are increasing in numbers, giving very cheap water with present low prices of oil.

(8) A desire on the part of some plantations to record the water going to the fields. The orifice type of instrument mentioned previously will supply a need.

To mention irrigation for the year without mentioning drainage would be a mistake.

Drainage

Drainage is equally as important as irrigation, and is linked with it. The Islands have always had an open drain system, but the use of tile drainage is a new thing to us, although it is not to the mainland, where thousands of acres have been reclaimed, salt lands being made arable.

R. A. Hart, of the Bureau of Public Roads, U. S. Department of Agriculture, came to the Islands this year to study the drainage of the following plantations: Laie, Koolau, Ewa, Makee, Koloa, Olaa and Kekaha. The plantations bore Mr. Hart's traveling expenses on a pro rata basis. He spent two months in the territory and his report will be available during the coming year.

The importance of this subject is best answered by the letter sent in by Manager George F. Renton, Jr., of Ewa which follows:

Ewa Plantation Company has been operating a tile drainage system since May of this year. The tiles are buried in a field of 58 acres, according to an experimental scheme worked out by Mr. Hart, Senior Drainage Engineer of the U. S. Department of Agriculture. The questions which it is hoped to answer are:

(1) Is the draining of sugar cane land by means of tile practical and profitable?

(2) Will increased yields of cane result from a lowering of the ground water table?

(3) Will it be easier to ripen the cane and increase the sugar content?

(4) Will the accumulated salt be leached out?

(5) Will the cane require less water on account of an increased root growth?

(6) In installing a tile drainage system for sugar cane under Ewa conditions:
- (a) At what distance should the laterals be placed?
- (b) At what depth should the tile be buried?
- (c) What size should the tiles be?

(7) Do our fertilizers—nitrogen, potash and phosphoric acid,—leach out of the soil or are they fixed immediately?

The experimental data to be secured by the plantation is large and involves:
- (a) Measurement of the water applied to the field and the amount of water discharged at the outlet of the drains.
- (b) Soundings of the ground water in almost 100 observation wells located at necessary points in the field.
- (c) Analysis of the drainage water and ground water.

The field in question should in time show the value of the drainage work for Ewa. Tile drains to the extent of some 12,000 feet of 8-inch and 4-inch tile were laid, and as Manager Renton says above, complete records are being kept that they may know if the installation was worth while.

Waipio had a spot of about one acre which never yielded any cane, the cane drying out completely in parts. Several open drains were cut, the water table lowered from 1½ feet to 2½ feet or 3 feet, and now heavier yields are obtained than in any other part of the field.

Kekaha has a 500-acre swamp. Manager Faye has an extensive project started in draining this gradually, and pumping the water from the swamp by a Semi-Diesel engine to a higher sandy area adjoining new land.

Some of the advantages of drainage are:

(1) Removing harmful salts.

(2) Lowering water table. Making a more uniform water table for a fluctuating one is bad.

(3) Excess water removed.

(4) Better aeration of soil.

(5) Soil temperature raised.

(6) Deeper root area.

(7) Better quality of juices expected.

The Straining of Raw Juice*

By S. S. Peck and E. W. Greene †

The present practice of straining raw mill juice consists in passing it through perforated metal strainers which catch the larger broken cane particles, removing them by scrapers and carrying them back to the mill. The object of this straining is to remove such particles as will interfere with the work of the pumps and distributing systems of maceration. The size of screen opening varies widely in different factories. It is generally stated in number of openings per square inch, and ranges from 72 to 225. These are controlled by the width and length of the strainer, the rate of travel of the scrapers, the variety of cane ground, the condition of the returner bars and grooves, and the quality of the preparation of the cane and milling. The system makes no pretense of removing all the suspended matter, which amounts to from 0.3 to 0.7% dry matter on juice. This consists of broken cane fiber, fine trash fiber, and the dirt and soil brought to the mill on the cane. The presence of some of the cane particles has been found necessary to insure a press cake that will filter well and wash rapidly. In fact, instances are known where the size of the openings was increased because of this reason alone.

In several reports of this Association and of the Hawaiian Sugar Planters' Association, the views of several writers have been quoted stating the desirability of replacing this part of the milling equipment with something better, not only because of the mechanical difficulties arising from broken chains, broken screens, etc., but principally because this station is a breeding place of infection and fermentation of the adhering cane particles, whence contamination of the whole juice is aggravated. Steaming the upper surface of the screen, chains, and slats reduces this danger considerably, but the lower surface of the screen is not reached and presents a large and growing bacterial population to the juices passing through. It is difficult, almost impossible, to keep clean, but is a necessary evil in the milling equipment.

With a view to removing further amounts of suspended matter, finer perforated screens have been tried on the mill strainer, up to 625 openings per square inch. Trouble usually followed due to particles of cush-cush being forced by the rubbing action of the scrapers into the openings and eventually reducing the straining area. This could possibly be corrected by using woven-wire screens with the same size opening and presenting a much greater straining area, but these are impracticable where the accumulated material has to be removed by such a means as the scrapers. Trouble also developed at the filter-presses which reflected the absence of the filter-aid of the fiber particles in size between the 625 screen and the larger mesh.

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*Presented at the second annual meeting of the Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

† Sub-Committee on Juice Straining and Juice Strainer, Association of Hawaiian Sugar Technologists.

During the past two years the attention of sugar house operators has been occupied with studies of methods of improving our raw sugars for refining purposes. After the report read last year on this subject, it was decided to concentrate attention on the study of the causes of and possible remedies for the difficult filtration of our sugars as contrasted with foreign products. This has been very thoroughly investigated by the Station and forms a part of a report to this meeting by W. E. Smith.

Among the remedies suggested at the last meeting was the fine straining of the raw juice; that is, it would appear that if this juice were freed of the greater bulk of its suspended solids before liming and heating, it would give a clearer clarified juice and also a cleaner sugar. The theory was, that in boiling this material in sugar liquors in the presence of lime, there was either a solution of certain components of the cane fiber or a hydrolysis of some of the constituents into soluble compounds. Several laboratory tests have shown that boiling juice in the presence and absence of matter which can be removed by straining through a fine mesh screen shows decided differences; without straining the resulting clarified juice had a lower purity and contained a larger percentage of solubles precipitable by alcohol than was the case with the strained juice. Later investigations have shown that such dissolved impurities do not play a very important role in making for poor filtering sugars, although they contribute to it. But it has also been found that fine straining before liming and heating does improve the filtrability of the resulting syrup, due to a reason which will be brought out in Mr. Smith's report on this subject. One experiment gave the following results:

	Unstrained	Strained
Purity	86.7	87.7
Filtration Rate of Syrup........................	40.0	49.0

Strainers

Four types of strainers have been brought to your attention, three of which have originated in Hawaii. The *Carter Defecated Juice Strainer* was intended originally for the treatment of clarified juice, as the name indicates, and was later tried on raw juice.

It consists of three inverted conical screens, one above the other, mounted on a vertical, rotating shaft, the whole enclosed in a steel plate housing. This apparatus was installed at Waipahu early in 1923 for trial in screening raw juice after it passed the regular mill strainers.

The Carter strainer did not operate successfully under these conditions and it was removed from the Waipahu Mill.

An inclined juice screen operating by gravity and without moving parts has been in use during all of the 1923 crop at the mill of the Oahu Sugar Company, Waipahu. The screen frame is set at such an angle that when raw juice is distributed at the top of the incline it will pass through readily at the same time washing the separated suspended solids gently toward the lower end of the screen where they discharge.

During this year the fineness of screening was limited by certain features of the mud station. However, with 50-mesh screen there was a separation of

70 to 75% of the suspended solids. The cush-cush was discharged in satisfactory condition without excessive dilution.

Changes are now being made in the mud station and it is anticipated that next year either 80 or 100 mesh screen can be used.

At Kahuku a revolving juice strainer has been in operation all season. During the early part of the crop only half the juice was strained, so as to allow some bagacillo for the presses. Since July 5th all the juice was strained. This strainer was also put in at the factory of the H. C. & S. Co.

Capacity

At Puunene all the juice from the crushers, first and second mills of the two tandems was taken care of by a six-foot strainer. This amounted to about 19,000 gallons of juice per hour. The machine was a little crowded; it would be safe to say that the capacity is 16,000 gallons per hour.

Material Removed

In an installation at Los Mochis, 75% of the suspended solids was removed by a strainer covered with an 80-mesh screen, the suspended solids dropping from 0.4% to 0.1% of juice. At Puunene it amounts to a similar quantity, being about 0.3% of the cane. On a crop of 200,000 tons of cane this would be equivalent to 1000 tons of bagasse of 42% moisture, or a direct fuel saving to that extent.

Nature of Bagacillo Removed

Because of the straining action of the bagacillo itself, much material smaller than the screen openings is taken out of the juice. In one test at Kahuku it was found that of the dry matter removed from the 100-mesh screen, 50% was smaller than this sized opening. It was an occasion of very dirty cane, and the bagacillo discharged from the strainer was chocolate colored.

Quality of Juices

The change due to the elimination of this matter on the quality of the juices was particularly noticeable at Puunene. The Dorr clarifiers had already made for a very much improved condition of the juices over previous years, but after the juice was fine strained a further very decided improvement resulted. The syrup from these juices was now clear and brilliant. It had a filtration rate at least 50% better than syrups from adjoining factories. A sugar made from this syrup, straight strike, and washed, gave a filtration rate of 116; the same unwashed was 109; and from a mixed strike 100.8. The turbidity of the sugar was 68 washed, 45 from the regular strike, and 28 from another factory doing usual work. At Kahuku since July 5th, and thereon to the end of the crop, all the juice was strained. There was an immediate improvement in the quality of the liquor, which was later shown in the sugars. They were able to carry a higher alkalinity than formerly, and had no trouble in the settling tanks as regards rate of sedimentation. There was a congestion here for another reason, which will be described later.

Filter Presses

At Puunene under the Petree process there was naturally no filter press problem. At Kahuku, as soon as all the juice was sent through the strainer, there was an immediate response at the presses, the juice and mud spurting through the cloths, only a thin film of mud forming before the presses stopped running, and a sludge remaining which could not be sweetened-off. This was corrected by liming the settlings to distinct alkalinity, bringing to a boil, after which a perfect cake was formed, the rate of filtration was better than ever before, and the cake could be sweetened-off to 2% polarization in the usual time of washing. On emptying the presses they were found with a full cake at each frame, up to 1¾ inches thick, with only about 62% moisture, and so dry that they fell off the cloths readily, leaving clean cloths. Instead of being crowded with five presses, it was found possible at times to do the work with three.

In liming the settlings to this alkalinity, it was not thought good practice to mix the press juice with the clarified juice to the evaporators, so the press juice was sent back to the raw juice. This additional juice along with the washings crowded the settling tanks, which were rectangular tanks, 4 feet high, with the lowest draw-off one foot from the bottom. The difficulty was overcome by emptying the settlings after every second fill; that is, the draw off to the presses amounted to one-seventh of the volume of juice instead of one-fourth as was the case formerly. There was no further trouble; the second settling took place as rapidly as the first. The juices were clean at all times, and the presses were easily capable of handling all the work.

Criticism might be offered toward this practice of high liming the settlings, with the possible effect on glucose and darkening of the juices. No such condition was observed. It is very possible that the time of heating and contact with the high alkaline solution is not of sufficient duration to make for any decided reaction in this respect.

The effectiveness of the straining was shown at Kahuku in two products. The clarified juice was as usual run over a 100-mesh screen, but there was no longer any need for it, as practically nothing was collected thereon. A sample of cake was washed through a 100-mesh screen, and left only 0.28% dry residue, whereas the ordinary cake showed up to 20%.

A report from Kahuku to the committee on boiling house methods shows the quality of the work obtained there as regards waste molasses for the 1923 crop. There were possibly several contributing factors to this excellent showing, but it is thought that the remarkably free character of the low grade products was primarily due to the effect of the strainer.

A further interesting development in milling practice is the invention by the Honolulu Iron Works of a pump which will handle unstrained juice with all its accompanying coarse cane particles. From this will be possible the practice of returning juices intended for maceration without straining, relieving the equipment of this part of the mill strainer and correcting the objectionable practice of saturating partly exhausted bagacillo with the richer juices from the first mills. It is further suggested that the mixed juices be elevated by the same kind of pump through a fine-mesh screen so that the straining can be done in one

operation and the present type of mill juice strainer be entirely discarded. The separated material can be brought back to the mill by a scroll conveyor; or where conditions permit, the strainer can be placed directly over the mill at a place where the removed bagacillo will drop directly onto the bagasse blanket.

Report of the Committee on Petree Process*

By S. S. Peck †

As the result of one season's operating with the Petree Process at the factories of the Hawaiian Commercial and Sugar Company and Maui Agricultural Company, the experience of those operating will be of unquestioned value to the members of this Association.

As a matter of particular interest, we include as a part of this report a letter from Mr. E. E. Hartmann, an old time resident and chemist of Hawaii, now connected with Petree & Dorr Engineers, Inc. As stated by him, his calculations are based on figures supplied him from the factory records, all of which have been derived in the usual manner, with some modifications added to take care of the conditions which differ from the usual mill practice.

One question which is usually asked is: "What is the effect on the mill rollers?" At Puunene there was no question but that the return of the hot mud affected the roller surfaces very adversely. It appeared that the polishing action was not so much due to the mud itself as to the absence of the natural acidity of the juices in the blankets, whereby the roller surface was not continually being roughened by the etching action of the liquors in the bagasse. This was evidenced by the fact that the rollers lost practically no metal during the season. But, particularly in the case of the top roll in the fourth mill, where it might have been expected that this action would be the least effective, it was necessary to regroove very frequently. All the top rolls are grooved eight to the inch. As a consequence of the polishing, there were frequent chokes at the mills with corresponding delays. This condition was partly corrected by (1) using old maceration water. The colder the bagasse blanket the better it seemed to feed. (2) By cooling the settlings returned to the mill. In both these cases we explain the improvement by the lesser swelling of the fiber particles due to the high heat. (3) By fine straining of the juice before clarification. The evidence was particularly noticeable at the first mills, where that side of the rolls to which the returned cush-cush was directed lost its polish after a few days. It is also explained by the probability that in removing the fine absorbing cane particles, we were returning less material of alkaline nature to the mill and restoring to a large extent the acid reaction of the natural cane juice.

* Presented at the second annual meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October, 1923.

† Sub-Chairman, Committee on Petree Process.

At Paia there was much less slippage at the mill, although it occurred to some extent. It is probable that this was due to either the Meinecke chutes, which allowed a slower and better penetration of the mud into the bagasse blanket, or to the coarser grooving of the top rolls, which was four to the inch. There was no strainer at Paia and hot mud was returned, but it was found advisable at times to use cold maceration water.

The next usual question is: "How about the extraction?" For the purpose of comparison, the figures for 1922 and 1923 are given:

	Puunene		Paia	
	1922	1923	1922	1923
Cane, Polarization	14.78	14.25	13.54	13.45
Cane, Fiber	12.53	11.95	11.83	11.76
Dilution % Normal Juice	36.09	38.11	25.57	47.95
Extraction	98.19	97.02	96.99	97.56
Extraction Ratio	.14	.25	.26	.21

It is to be noted that the differences between the two years should be a little greater because of error in calculation of bagasse weights due to the returned insolubles in mud.

We feel certain that the extraction at Puunene was low on account of the large volume of juice returned to process with the mud, thus preventing the proper circulation of return maceration in the usual manner. This amounted to about 30% of the cane. A calculation with definite assumed figures of fibres in bagasse and factors for admixture of maceration water substantiates this. During the 1924 season, with a better acquaintance of the conditions attending the process, it is expected that a return to 98 or better will be obtained.

At Paia better results for 1923 than obtained in 1922 as regards extraction were shown, but the dilution figures explain this. The 1923 extraction figures would have been still better had it not been for some trouble at the last mills in the driving gears which could not be corrected until between seasons.

Another question is: "Was the anticipated fuel saving realized?" There was a very decided saving at Puunene, so much so that at times up to 600 kilowatts were furnished for outside power from the mill power plant, and no oil was burned after the month of February. There were other conditions aside from the Petree Process which contributed to this economy. Some changes made in the boiler installation were largely responsible, and molasses was burned under the low pressure boilers. It is therefore difficult to estimate how much of the reduction in the fuel bill is due to the process, but it is certain that from the less loss in radiation, the elimination of the filter-press station, and the extra fuel from the returned mud, this was no small figure.

At Paia, other conditions existed. The irregular grinding and the poor work at the last mill, leaving a high moisture in bagasse alone, explain the demand for extra fuel which was greater than in 1922, but less than in 1921. The difference in results in the two factories makes any positive statement in this connection quite impossible.

Recovery

In both factories there was a higher recovery reported than in previous years. In attempting this comparison, it must be remembered that there is no mixed juice figure on which to base a strict comparison. We have made a calculation for Puunene, starting with the crusher juice, which is a fairly reliable figure in this factory, and calculated a theoretical recovery from these purities, 100 extraction, the purity of the sugar as produced, and a 36 gravity purity molasses. This figure compared with the actual recovery takes into account any improvement due to clarification. A comparison of three years follows:

Recovery % Polarization in Cane	1921	1922	1923
Theoretical Recovery	93.93	93.90	94.42
Actual Recovery	89.61	88.57	90.77
Efficiency	95.40	94.32	96.13

It is to be noted that in 1921 the cane was ground in a 15-roller mill. The figures reflect approximately the savings due to no filter-press losses, to less undetermined losses, to a better rise in purity during clarification (measured by the less drop in purity from crusher juice to syrup) and include also the greater loss in extraction in 1923. While not above criticism, we believe these figures demonstrate a real gain in sugar in bag over the previous years.

Quality of Products

The clarification of the juices, the resulting syrups, the commercial sugar, and the low grade work were all favorably affected. The juices and syrups were brilliant; the sugars cleaner than even with the juice filtration previously practiced; and the low grades worked so much better that only 60% of the low grade centrifugals were required throughout the crop.

Labor Economies

There was no saving in labor costs in the milling department, but in the boiling house there were less men used because of the elimination of the filter press station and the running of a less number of low-grade centrifugals.

[Copy of letter to S. S. Peck* from E. E. Hartmann of Petree & Dorr Engineers, Inc., New York, N. Y.]

Having arrived in Honolulu after the two Petree process plants had shut down, I can, of course, only comment on the results.

The outstanding feature of these results is the 3% increase in boiling house recovery (2.93% sucrose in cane as compared with 1921, and 3.11% sucrose in cane as compared with 1922, based on the theoretical recovery of 1923).

There has been a loss in mill extraction, amounting to 1.45% sucrose in cane as compared with 1922. 1921 cannot well be compared with the last two years, as five mills were used in that year.

The net gain was 1.67% sucrose in cane or more than 800 tons of sugar.

* Sub-Chairman, Committee on Petree Process, Association of Hawaiian Sugar Technologists.

We have every reason to look forward to a much better total recovery next year, as steps are now being taken to remedy the conditions, which led to the falling off in extraction.

A good deal of mud was circulated (Mr. Peck found the settlings to amount to as much as 30% of the cane). It looks to me as if the Ramsay macerator were not a suitable distributor for the mud. The impression I have received from descriptions of this operation, is, that where the macerating mud strikes the surface of the rather compact blanket of bagasse, the clear liquid is absorbed, the mud forming a cake on the surface, clogging it against access of more macerating mud. As a result a portion of this mud seems to have been carried in pockets to the third mill, there to be re-expressed.

The absorption of this mud in the bagasse is clearly a function of the surface of the latter. At Puunene this surface area was very restricted. One way of remedying this condition would be to break the blanket of bagasse and to apply the macerating mud from the top at the point where the blanket is broken, thus increasing the surface area of the bagasse.

A radical change in procedure, such as is introduced by the Petree process, is sure to cause temporary disturbances in the factory and it also may affect methods of control. This fact has naturally given rise to a number of objections and criticisms, which I shall here discuss and answer as far as they have come to my notice.

In calculating the mill extraction, it is necessary to take cognizance of the fact that the insoluble matter returned to the bagasse carries off as much, or practically as much, sugar as the insoluble matter in the bagasse. In this instance we find the bagasse % cane originally reported as 21.68%. To this we have to add the bagasse equivalent of 1.02—.07=.95% insoluble matter in mud, or .95 : .55=1.73% cane. The sucrose % bagasse should therefore be multiplied by 21.68 plus 1.73 = 23.41 instead of only 21.68, and the loss in bagasse % cane is then correctly given as .457 instead of .42.

A question, which the introduction of the Petree process has brought up is: "To what extent does this change in procedure affect the sucrose value % cane?"

A slight correction should be made for both the Petree and the filter press methods of working, as shown below.

Where filter presses are used the figure for bagasse % cane was slightly too high, because the fiber in the bagasse is compared with the total fiber in cane and not, as it theoretically should be, with only that portion of the fiber which goes into the bagasse.

A similar small correction should be made where the clarified juice is weighed, as in this case the fiber in the bagasse should be augmented by that portion of insoluble matter, which was not originally in the juice.

These two small errors are cumulative in comparisons, as they tend to make the figure for sucrose % cane slightly too high where the mixed juice is weighed and slightly too low where the clarified juice is weighed.

The insoluble portion of the material entering the mill appearing on factory reports as "gross fiber in cane" has only one outlet in the Petree process and that is in the bagasse. Where filter presses are used, a portion of this insoluble matter finds its way into the presscake.

In the Petree process the ratio: insoluble in bagasse to insoluble in cane gives a value for bagasse % cane, which for complete accuracy would have to be increased by the percentage of solids precipitated from solution in the juice together with the lime contained in the precipitate. The organic matter precipitated from the juice can, if in the absence of data on the formation of volatile products we may ignore this factor, be approximately measured by the increase in purity of the juice during clarification. This increase has been about 1 in 1921 and 1.1 in 1922. This increase is equivalent to the elimination of .15% cane of solids of the specific gravity of sugar.

If the press cake amounts to 2.5% of the cane and contains 8% of lime, the lime in the precipitate would amount to .20% cane and the total precipitate to .35% cane.

If this precipitate carries off as much juice as the bagasse, the bagasse equivalent would be .35 : .55 = .64% cane.

The bagasse % cane is originally reported as 21.68, the increase due to the addition of this precipitate is therefore .64 : .2168 = 3.0% and the sucrose in bagasse % cane is increased by 3% of .42 or .013 making the true loss .433 instead of .42%, and the percentage of sucrose in the cane 14.263 instead of 14.25.

Where filter presses are operated, the ratio: insoluble in bagasse to insoluble in cane gives too high a figure for bagasse % cane, as pointed out above. The correction applied to the 1922 figures was arrived at in the following manner:

Sucrose in bagasse % cane as reported	.27
Sucrose in juice % cane as reported	14.51
Insoluble in press cake cane as reported	1.02
Precipitate from clear juice % cane	.35
Insoluble originally in juice cane	.67

.67 : .55 = 1.2 bagasse equivalent % cane.
1.2 × 100 : 21.75 = 5.5. 5.5% of .27 = .015.
True sucrose in bagasse % cane = .27 — .015 = .255 instead of .27.
True sucrose in cane = 14.765 instead of 14.78%.

These corrections are small, still they should be applied when making comparisons.

The introduction of the Petree process has given rise to the question, "Does the substitution of the clarified juice for the mixed juice as a basis for the calculation of the sucrose in the cane affect the latter figure, in other words, is it not possible that a loss of sugar occurs in the process of clarification?"

We know that inversion cannot take place in a sufficiently limed juice. Just at what point of alkalinity a juice may be said to be sufficiently limed has so far been purely a matter of opinion. Experiments recently carried out at the H. S. P. A. Experiment Station indicate that there is no inversion in a comparatively heavily limed juice, while on the other hand, inversion does take place in juices held at a temperature of 212° F. for a number of hours, even if slightly alkaline. The exact danger point has not yet been established, and it is conceivable that this point may be a different one for different varieties of cane.

That no measurable loss had been sustained in clarification at Puunene is evidenced by the Java ratio which was 82.15, 82.39, and 82.37 for 1921, 1922, and 1923 respectively.

The above leads to the conclusion that the sucrose weights obtained from the mixed and from the clarified juice are strictly comparable where juices are properly limed.

The question has been put to me: "Granted that a much higher recovery has been coincident with the operation of the Petree process, is this due to the Dorr clarifiers or to the double clarification, or to the elimination of the filter presses, or to the well known fact that more attention is paid all around when any important change is made?"

I have no doubt every one of these factors helps in bringing about the improvement in recovery. Just what share each of these factors contributes, I don't know.

In regard to the first item I would report, that while the Dorr clarifier admittedly gives better clarification than any other clarification system and consequently a better product, the earlier successes of the Petree process were obtained without it.

It is reasonable to expect that double clarification of the more impure fractions of the cane juice will secure a more complete elimination of the impurities, particularly of those, which are in a very finely divided or even colloidal state. The juice which undergoes double clarification consists of the fractions extracted by the second and subsequent mills, the juice contained in the mud of the primary clarifier, which latter should never amount to more than 10% of the weight of the cane—at Soledad it amounted to from 5 to 8%, and the clear juice from the secondary clarifier.

That there is an agglomeration of particles in the secondary clarifier different from the ordinary mud, can be clearly seen when comparing the mud discharge from the primary and secondary clarifiers. Whereas the former has a thick and slimy appearance, the latter consists of a freely running mixture of juice of low viscosity with a granular mud.

At Soledad this difference was very striking and yet the percentage of insoluble matter in the heavy primary mud and that in the fluid secondary mud was approximately the same, varying between 8 and 10%.

That a large portion of these substances, gums, waxes, and possibly starches, which are present in the juices in a condition so nearly akin to solution that the juice containing them may appear quite clear to the eye, are eliminated by this procedure, is evidenced by the better boiling quality of the intermediate products, and by the better quality of the sugar.

Now we come to the filter presses. That there are losses sustained in their operation, which do not appear in the figure for loss of sucrose in press cake, will be generally admitted. The item, undetermined losses, covers as we all know, a multitude of sins, but there does seem to be a tendency for these losses to be highest when the loss of sucrose in press cake is lowest. Is it not probable that an appreciable amount of deleterious impurities are redissolved from the press cake while washing?

There are other drawbacks to the operation of filter presses. In the best regulated filter press station, defective cloths will be found, and consequently a faucet here and there will discharge muddy juice; cloths may sometimes not be properly put on and a press may leak on the side. There are so many chances for some of the very fine mud, which we know impairs the boiling house work, to find its way back into the clarrified juice.

The last factor mentioned, the psychological one, contributes its share unquestionably to better efficiency. It is so intangible however, that whatever benefit it brings may well be credited to the change which introduced it.

I should like to refer to one more suggestion which has been made, and that is, that the quality ratio be used for comparing one year with another.

The quality ratio is based on a constant for loss in press cake and undetermined, and on another constant for the difference between the crusher juice and syrup purity.

As it is just in these items that the Petree process shows the greatest improvement over the older methods, the use of the quality ratio as a basis of comparison between the two methods of working, is out of the question.

If the combined action of all the factors above enumerated brings about such a decided improvement in boiling house recovery and general working conditions in addition to the direct savings in labor and supplies and a product of better quality, are we not justified in judging the process by its results, leaving the analysis of the various phases and the apportionment of the credit properly belonging to each, to the time when sufficient data will be available to do so?

The fact remains that the Petree process has saved the owners of the factory three dollars on every ton of sugar, and there is every reason for expecting better results next year.

I leave Honolulu feeling confident that the process will have the benefit of the same searching and fair scrutiny next season as it had the past year.

Report of the Improvement of Cane by Selection*

By F. A. Paris

I do not feel like presenting to you today any results obtained up to now by bud selection work as I decidedly believe that it is too early. It would only lead to endless discussion of no practical importance and our meeting would come to an end without bearing fruit.

Environment, natural and artificial, causes such enormous fluctuations that only after many years of accurate testing of individuals and progenies, will any light be thrown onto the problem of bud selection. Besides that, certain defects in our methods are likely to lead to wrong ideas and premature statements. I shall come back to that subject in a later part of my report.

* Presented at the second annual meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

I divide selection work into two distinct fields of action, one of which is based on facts of immediate profitable influence on our industry, now and in the future:

1. Plantation selection or mass selection of seed. The other of a more experimental nature which may or may not be immediately productive.

2. Bud selection.

Plantation Selection

Let us briefly pass in review a few of the valuable points of mass selection. In any branch of agriculture its importance is recognized, anyone who has been farming in a temperate climate or knows anything about it, will agree with me. Years ago anything was good enough for seed, the cheapest was the best. The smallest potatoes, and even cut into small pieces, were picked out for planting, later on that method proved wrong and the best seed, and the most profitable, is a well-formed tuber of average size, with good eyes. The same opinion, that the best only is good for seed, rules for any other crop, and special machines have been invented for grading and special areas set apart for the production of superior seed.

In animal breeding too, great results have been obtained by careful, continual selection of the breeding stock. The importance of mass selection of seed in sugar cane is beginning to be noted, and is becoming a practice. I have not failed to be told whenever I saw a thin, weak stand of plant cane that the seed was poor, and the contrary whenever a new field made a good impression.

Mass selection of seed is a time and money-saving device on a plantation, as everywhere success depends upon a quick germination, a strong start of the vegetation and a good stand. In time it will be absolutely indispensable for the purpose of maintaining the pure strains that bud selection may isolate.

Once more I make the statement that mass selection of seed is indispensable for the success of our industry.

How could we systematize mass selection and introduce it as a plantation routine?

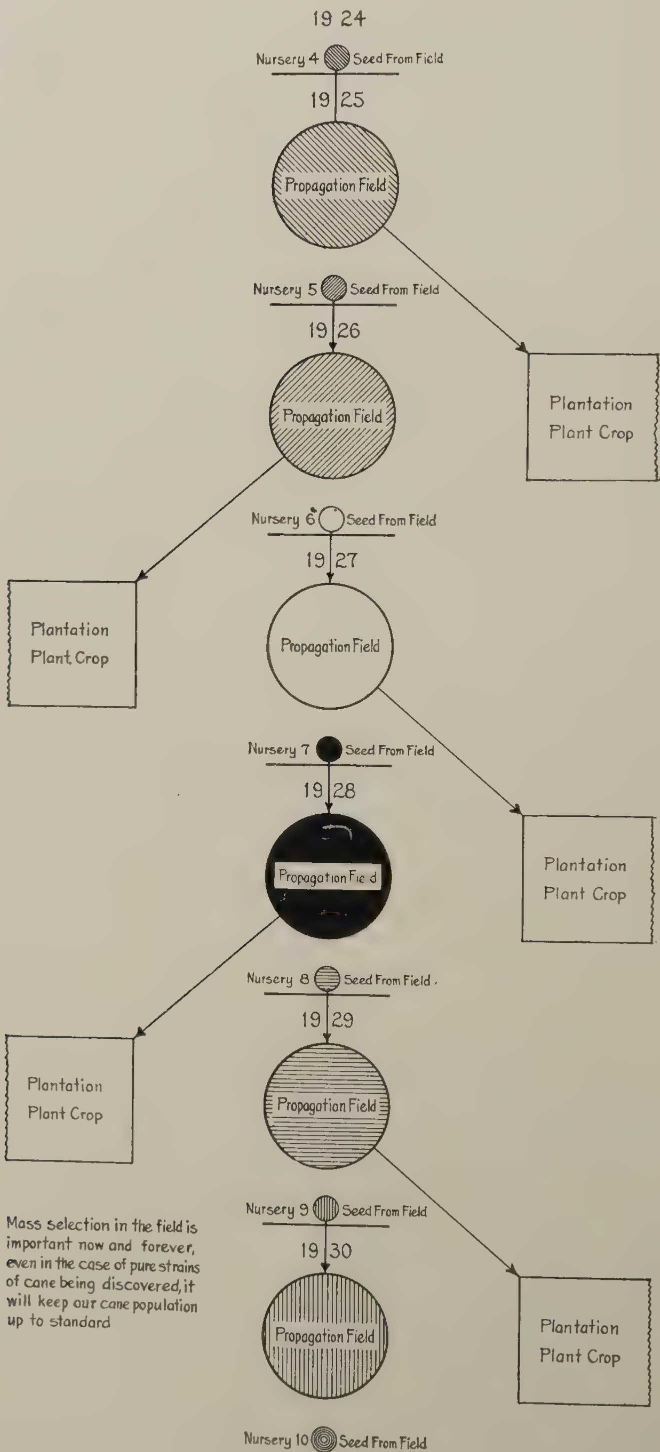
By instructing our seed cutters to leave out any weak or abnormal looking stalks, their eyes should be educated to recognize good and viable material. Besides the gang feeding the general planting we should organize a picked bunch of men under the supervision of a keen observer and collect with them the best seed there is, bag it in specially marked bags, the blue seed in blue bags, if I may express myself in that way. The picked seed should be planted in a separate section called field nursery, the same operation to be repeated every year. After one year in the field nursery the cane would be cut, reselected and the best planted in a so-called propagation field. From there, a year later, it would go as plantation seed.

The above method would lead to the establishment of an endless chain, an automatic grading of our cane population.

The following diagram will make clear to you, better than words, the layout of the scheme and its way of working from year to year:

Mass Selection Scheme For Plantation Seed. (Layout)

Propagation Ratio 1:5



Mass selection in the field is important now and forever, even in the case of pure strains of cane being discovered, it will keep our cane population up to standard

We make a point of obtaining our seed for the field nursery from the field, conserving, by doing that, the valuable collaboration of natural selection. We shall get a better average type, the fittest of the fit.

As we go forward with the establishment of new field nurseries and propagation fields the ones low down on the list drop out. The acreage of the field nurseries should be in proportion to the area planted each year by the plantation. We adopted the ratio 1:5:5, meaning that a one-acre field nursery will plant five acres of the propagation field and that, in turn, five times more of plantation cane. If a plantation is planting an average of five hundred acres a year the propagation field should be one hundred acres and the field nursery twenty acres, that ratio would allow a careful selection of seed each time.

To complete the subject let us recapitulate a few more important items connected with seed for our field nurseries:

I presume that we all agree that top seed from mature cane is the best. In full grown cane the better individuals stand out more clearly, the eyes of such cane are larger and ready to germinate and the young shoots will find in the seed piece better nourishment; thus they will get a better start. I must mention here an exceptional case, under very bad conditions hard seed will probably give better results, it will deteriorate less rapidly than a juicy seed piece and we can practically say that the better the seed the more attention should be given in starting prompt germination. We also agree that seed from ratoon cane is superior to that from plant cane as we are more likely to find desirable individuals in cane having gone through a period of adaptation. Ratooning power is a vital point for the existence of many of our plantations. It is everywhere a great factor in minimizing the cost of production. In the establishment of our nurseries during the first two years we may have to make an exception and cut young plant, but we should go back to our rules as soon as conditions become normal. A good many more field operations have an influence on growth and should go hand in hand with mass selection but we cannot discuss them here.

Bud Selection

Taking into consideration the great part which environment plays in creating fluctuations, differences between individual plants, I do not think that it is possible to admit that we can pick out types straight away, among our cane population. It is only after a certain amount of individual study that we shall be able to recognize facial differences between our plants.

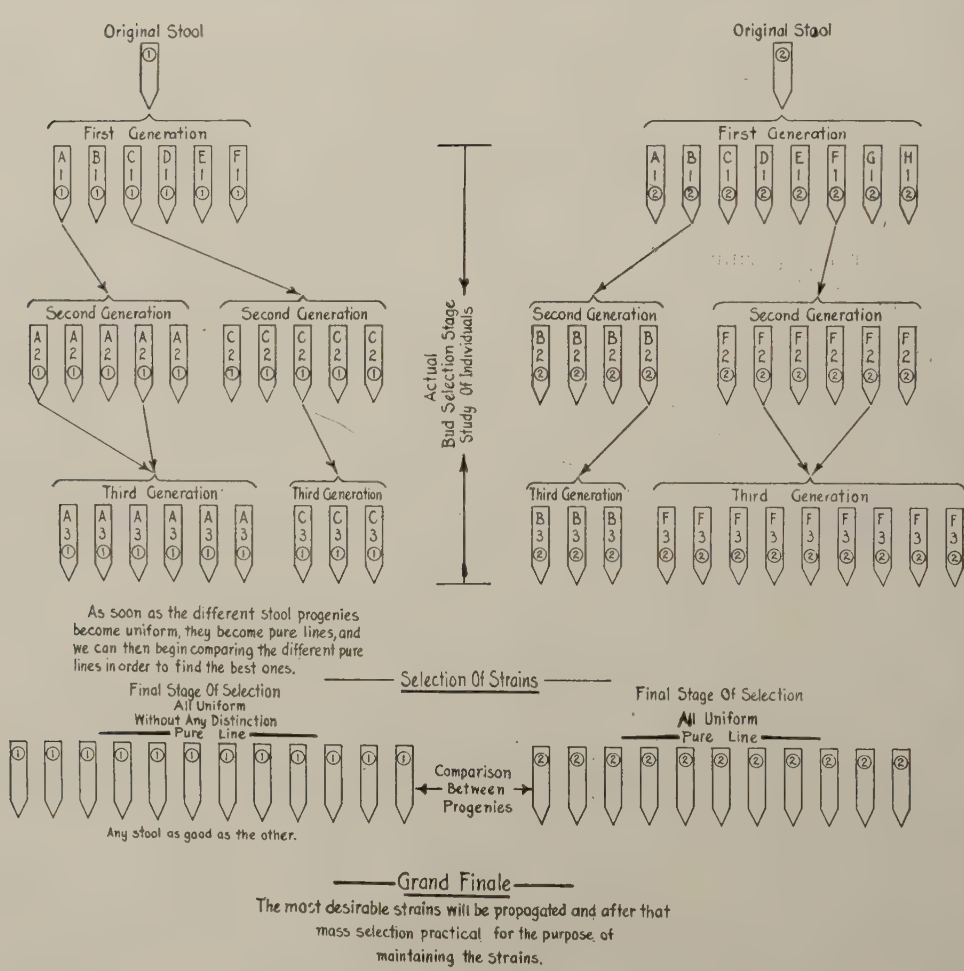
We should take as a unit first the actual bud until we are absolutely sure that we are dealing with pure strains. When that point is cleared up we can start a progeny selection or a type selection using the same methods we have already adopted. The present system has the disadvantage of going too fast. It makes any individual selection in the progenies impossible. You should not sail out of sight of the coast until you know how to take your bearings.

By carrying out, through several generations, a careful individual selection and an individual study of our cane plants we shall get to know the characteristics of the different types, making easier a later type selection suitable to our conditions.

The accurate knowledge we gain of the characteristics of types through individual selection and individual observation may be of great value for the improvement of our cultivation methods. With the present system we are trying to do two things at one time, mass selection or production of plantation seed, and bud selection. By dealing with a great amount of material accurate observation is impossible, and observation is the most important point in selection work.

I propose keeping back the present system for a while until we have isolated and studied the pure strains. It will not be a loss, as the plant material isolated up to now can be further investigated, and I advocate only a safer way of going forward into unknown territory.

BUD SELECTION AND STRAIN SELECTION SCHEME FOR STAKING



I suggest the following preliminary scheme:

Reserve a certain acreage in an accessible part of the plantation for the purpose of carrying out the first stage of our selection, individual selection in the progenies, where outstanding stools should be brought in, real queens which

would give the start to our progenies. These stools should be rooted out to make sure that they are from a single bud. It is essential before we start, to decide if we are looking for a type resistant to disease, or a high yielding type, etc., and collect our first material accordingly.

Personal disposition of the breeder has a great value as some of the valuable characters in plants or animals are hidden, they cannot be seen, so they must be felt.

An accurate record of the characteristics of the first stool must be taken, a photograph for general appearance and juice analysis would be useful besides other important details. The same system of weighing in use now would be kept.

Single-eye planting must be the rule until we reach uniformity among the individuals composing the progeny. Before cutting the stalks for seed, the best eyes should be picked out and the cane cut so that these eyes would be in the middle of a three internode seed piece. Each seed piece should have a node at each end for protection. The eyes should be planted three feet apart. Colors or names should make the distinction between progenies. Each eye in the first planting will get a letter which will be carried on from bud generation to bud generation to recognize the descendants from that eye. The generations will be recorded by numbers 1, 2, 3 and so on. The following sketch will explain the method of staking.

Once a definite proof is obtained of the uniformity of the material composing our progenies, we can calculate the average means for each and start our final selection, the type selection, on the same lines adopted now for the selection work started by Mr. Shamel.

Seedling work has a great importance beside bud selection and mass selection. Not only until we have found a few more cane varieties to suit our conditions, but also for the purpose of producing new varieties to take the place of our actual types of cane which may have lost the faculty of adaptation to an ever-changing environment.

Report on Soils and Fertilizers

By W. T. McGeorge

In preparing the report on soils and fertilizers an attempt has been made to cover, superficially, the activities and developments of the past year leading to a more complete understanding of our soil and fertilizer problems. Details are avoided, to eliminate duplication. On the other hand, a brief notation of all activities will add greatly to the future value of these reports and serve as an incentive for discussion at these meetings if details are desired. At present, practically all work of this nature has been performed at the Experiment Station, but it is to be hoped that in view of the broadening of the activities of the Technologists' Association, in the future wider attention will be given to this phase of the problems of our industry.

Soil Analysis

Soil samples are often submitted to the Experiment Station for analysis from which fertilizer recommendations are solicited. Mainland experiment stations are attempting to discourage such a practice, and rightly so, for the range of variation is too great in diversified agriculture. A definite association between chemical composition and fertility has thus far failed to materialize under such conditions.

Where we are concerned with only one crop our case is more specific. The value of soil analysis is therefore not beyond the range of possibility and in an industry such as ours, in which heavy fertilization plays an important role, the application of soil analysis would be of considerable value had we sufficient data on which to formulate a policy.

In the past it has been the practice of the Experiment Station to make interpretations from data based on analyses of samples representing comparatively few field experiments. Further analyses of Island soils of known history have added data, the value of which is strikingly apparent.

Phosphates. Since the data are being submitted in complete detail elsewhere only the results obtained with 1% citric acid, which proved to be most closely related to the results obtained by field experiments, are submitted here. A summary appears in the following table:

	Soils giving no response	Soils giving response
Average	.0320	.0014
Maximum	.3190	.0028
Minimum	.0026	.0006

The above is an average of 39 composite soil samples from 22 field experiments located on the four major Islands. On the basis of the above and as a matter of policy, variations being admitted, the following suggestion has been offered. A plantation soil showing .0025% P_2O_5 or less, soluble in 1% citric acid will, with rare exceptions, respond to phosphate applications when planted to sugar cane. Soils within the range of .0025 to .0040% present a condition in which the availability is governed more or less by other factors and it would be the better policy to depend on field experiments in such cases. Finally, with rare exceptions, will soils showing greater than .004% P_2O_5 soluble in 1% citric acid respond to phosphate fertilization.

Potash. Soil samples taken from 17 field experiments located on 13 different plantations on all four Islands were analysed by several methods and 1% citric acid was the only solvent which showed any promise. The results obtained by this method are summarised as follows:

	Soils giving response	Soils giving no response
Average	.014	.054
Maximum	.024	.082
Minimum	.007	.031

On the basis of the above, the following policy has been suggested. A plantation soil showing less than .02% K_2O soluble in 1% citric acid will, with rare exceptions, respond to potash applications. Those soils within the range of .02 to .03% may be considered deficient in available K_2O and, depending on certain factors, will usually give a slight response while the soils above .03% K_2O will rarely give profitable returns from potash fertilization.

Factors Influencing Availability

While it is possible to definitely determine the solubility of any phosphate or potash compound in any solvent, a great number of factors which will limit the application of such solvent power to soils must be admitted. A consideration of some of these must be considered in interpreting soil analyses and limitations accordingly allowed.

Silica. A definite relation between the solubility of silica and availability of P_2O_5 as measured by 1% citric acid has been shown. A greater solubility of silica accompanies a greater availability of P_2O_5 and also a greater assimilation of P_2O_5 by the cane. Juices from cane grown on such soils are higher in P_2O_5 content. On the other hand there appears to be little or no relation between this factor and availability of potash.

Soil Acidity. The higher acidity of soils giving response to P_2O_5 is significant. The same is true of those soils responding to potash.

Lime. In general, the soils giving response to phosphate are lower in total lime, that present as carbonate, sulphate and easily soluble silicates and more especially that soluble in water saturated with carbon dioxide. We have also noted a greater assimilation of P_2O_5 on the high lime soils as shown by the higher P_2O_5 content of the juice. Again, in the soils from the potash experiments we have found considerably larger amounts of lime in those soils which field experiments show to be amply supplied with available potash.

Mechanical Composition and Availability. There appears to be little or no relation between the relative size of the soil particles and availability of phosphoric acid. On the other hand, the higher clay content of the soils giving no response to potash is significant. Also, color and organic matter appear to be related to availability of potash, being of higher availability in the red clay soils than the yellow type. Availability also appears to be lower in the highly organic soils.

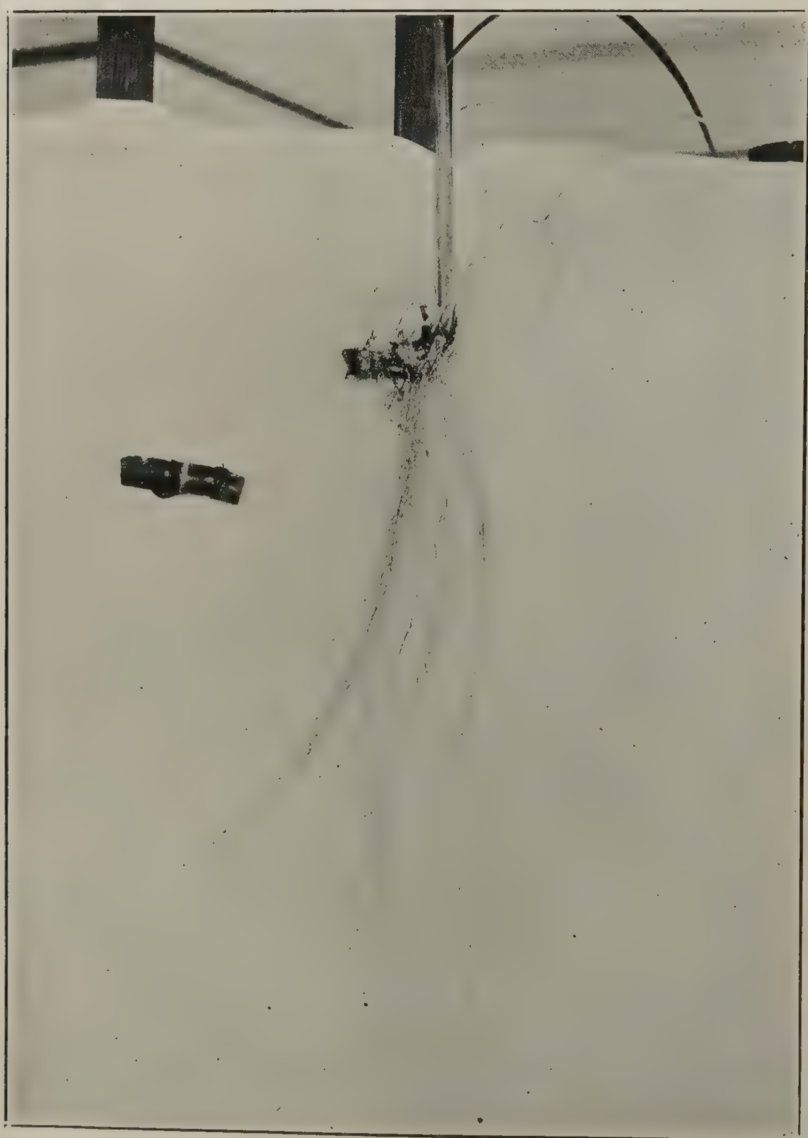
Hence, in making interpretations of the analyses of Island soils suggestions are not offered from the P_2O_5 or K_2O determination alone. Allowance is made for the influence of other factors and a knowledge or history of the past performance of the field or soil type. No "hard and fast" rule is possible and it is therefore essential that new field experiments be followed up with soil analyses, thus adding valuable data to that already accumulated.

Nitrates Versus Ammonium Salts

The heavy nitrate applications are probably more directly involved in the heavy yields of cane on the Island sugar plantations than any one factor. Experimental evidence has shown that some crops will assimilate nitrogen as ammonia

and thrive normally in the complete absence of nitrates and nitrifying bacteria. As an illustration of local interest we may cite the rice plant. In view of the low nitrification in the acid Island soils the question arises: Is ammonia directly involved in the nitrogen nutrition of the cane?

Our experiments in water and sand cultures indicate practically no growth in the absence of nitrate. The buds may develop slightly if in contact with air but root development is almost completely lacking. The roots which do make a slight start are very dark in color and root hairs are almost entirely absent. The accompanying illustration shows the comparative growth of H 109 seed, grown for practically four months in sand cultures. These experiments clearly indicate the vital role which nitrates play in sugar cane nutrition.



Showing the root development in the presence of ammonium sulphate (left) and sodium nitrate (right).

Tolerance of H 109 for Sodium Nitrate and Ammonium Sulphate

When we attempt to apply the necessary fertilizer which is required to raise maximum cane crops under the most favorable conditions it is often asked, How much nitrogenous fertilizer can be applied without injury? In order to answer this an experiment was started in October, 1922. Uniform stools of H 109 cane, grown from single eye cuttings in small seed boxes were placed in large concrete pots.

In one series nitrate of soda was applied, in duplicate, in amounts ranging from 25 pounds nitrogen to 200 pounds nitrogen per acre. In another series ammonium sulphate was applied in amounts ranging from 50 to 200 pounds nitrogen per acre. Two pots were left untreated as a control. The first application of fertilizer was made approximately one month after planting. The above applications have been made each month making eleven applications to date. The cane receiving the heaviest applications of nitrogen in both forms has at times shown some signs of injury immediately following the fertilization. However, all the stools are still strong and healthy.

The drainage water from these tubs has been collected and analysed. Traces of nitrogen in the form of ammonia and nitrites have been leached out, but only moderate amounts of nitrogen as nitrate have been lost. The largest losses do not amount to more than 10 to 20% of that added. Evidently the soil or the crop has retained most of the nitrogen. The experiment shows that there is little danger of injuring the growth of cane plants by any application of nitrate of soda or ammonium sulphate which is likely to be made under field conditions.

Retention of Nitrates and Effect on Soil Reaction

The study of nitrogen salts and their effect on the soil reaction, on which a preliminary report was issued last year, has been continued. In the preliminary work it was found that ammonium sulphate was perfectly retained until nitrification took place. The ammonia radical was held in the top foot of soil. Sodium nitrate was washed down into the second foot and third foot in most cases and occasionally into the fourth foot by a six-inch irrigation. All the nitrogen salts showed some solubility effect on the soil minerals. There was more effect from ammonium nitrate and ammonium sulphate in rendering plant food soluble than there was with sodium nitrate. Sodium nitrate and ammonium nitrate caused a slight increase in the alkalinity of most of the soils used. Ammonium sulphate showed the usual slight increase in soil acidity.

Since completing the above laboratory studies two series of field experiments have been carried out in which nitrate of soda was applied to three typical soils at Ewa Plantation. All applications were made at the rate of 100 pounds nitrogen per acre. The nitrate was largely retained in the top two feet of soil, some penetrated into the third foot, but very little went down into the fourth. In several cases the irrigation water passed down to an appreciable extent into the fourth foot of soil without taking a corresponding amount of nitrate with it. This shows a better retention of nitrates in the undisturbed field soil than when packed in lysimeters.

The first season's application was absorbed out of the soil by the plant in about ten weeks or less. The second season applications were taken up more slowly but were largely used up within three months after application.

With some soils there was a slight increase in alkalinity, but this gradually disappeared. This gradual disappearance of alkalinity developed from nitrate applications was also obtained in laboratory experiments, in which soils to which sodium nitrate applications had been made were retained at optimum moisture content in jars. The effect of mixed fertilizers upon the soil was found to be somewhat similar to nitrate of soda. This change in the reaction of the soil is probably due to the high content of colloidal material in our soils and the correspondingly low percentage of silicates.

Organic Carbon

Studies on the carbon content of plantation soils show considerable variation in the organic matter present. The carbon content ranges from 1.02% to 13.11%, being highest in the humid districts on Hawaii and lowest in the dry sections of Maui and Oahu. Results indicate that as compared to mainland soils, analysis does not show too low an organic content. Data on mainland soils, however, do not necessarily apply, as the physical condition and water holding capacity of the red clay type would undoubtedly be greatly improved by additional organic matter. The principal properties which organic matter impart to the soil are greater water holding capacity and improvement in mechanical condition.

Other than the coral areas there is little or no carbonate carbon present. All non-coral areas were below .025% carbonate carbon.

The question has often been asked, Are we exhausting the organic content of plantation soils? In an attempt to answer this a set of 42 samples from Ewa Plantation were analysed for total carbon content. The results obtained are of unusual interest. These 42 samples represent cropped and uncropped adjacent areas of nine fields. Of these nine fields, four were lower in carbon and five were higher than adjacent border samples. The field samples varied from .85 to 1.93% with an average of 1.30 while the border samples varied from .74 to 2.68% with an average of 1.37. In other words, at Ewa plantation where crops are heaviest and trash burning always practiced there is no indication that organic matter is being depleted. Roots and stubble are apparently keeping it up.

Paper Mulch

Two of the principal factors involved in the stimulation of plant growth under paper mulch are temperature and moisture supply. Some experiments during the past year have added materially to our knowledge of the above properties of the mulch.

Temperature. Temperature records were made by standard soil and air thermometers. The differences between the soil with and without paper appear to depend on several factors. They vary with the general weather conditions and the temperature of the air. With bright clear weather and a fairly high temperature the temperature of the soil under paper may be 8 to 10 degrees F. higher at certain periods of the day. In general, in clear weather with tem-

peratures of 75° to 80° the difference will amount to 4° to 6° F. in the day time and 1° to 3° at night in favor of the paper. In cool rainy weather, these differences disappear and after a heavy rain the paper plot may have a lower temperture for a time as it warms up more slowly. Under half shade conditions the differences are much lower.

Evaporation. In this experiment it was found that the bare soil lost moisture three times as fast as the soil covered with paper. The paper covered soil lost the same amount of water in 18 days as the uncovered soil lost in 8 days.

Borax in Fertilizers

During the war, serious injury to field crops, from fertilizer applications, was noted on the mainland and traced to the potash salts which contained appreciable amounts of borax. This potash had been obtained from one of the emergency sources created following the cutting off of German commerce. In view of the fact that potash from this same source had been imported to Hawaii the question arose as to the toxicity of borax to sugar cane.

Experiments in concrete tubs comparing 50, 250, 500, 1,000, 2,000, 4,000, 8,000 pounds borax per acre indicate thus far a high degree of resistance of sugar cane to borax. On the plant crop no visible evidence of injury was noted with less than 1,000 pounds per acre and very little where 1,000 and 2,000 pounds were applied. On the mainland, amounts as small as 5 to 8 pounds per acre caused appreciable injury to potatoes, cotton, corn and tobacco.

Phosphoric Acid and Potash in Cane Juices

The study of the relation of phosphoric acid and potash in cane juices to the available supplies in the soil which was started last year at Pioneer Mill has been continued there and taken up in some detail at Ewa Plantation. These results are being presented by J. H. Pratt. For this reason, only those results published in the Record during the year and some observations made at the Experiment Station will be mentioned.

Phosphoric Acid. The results published by Mr. Walker to date indicate .01% P_2O_5 in cane juice to be the point below which phosphate manures should be applied. Those above .02% contain sufficient available P_2O_5 in the soil. At the Experiment Station we analysed juices from separate plots in experiments carried out at Oahu Plantation and the Waipio Substation, in which we were studying the changes in available phosphoric acid in the soil. The former gave response and the latter no response to phosphates. This data is being prepared for publication along with the soil studies. Suffice it to say that the juice from Oahu Sugar Co. contained .008% P_2O_5 while that at Waipio contained .026% to .029%. The latter area is slightly higher in available phosphoric acid but not markedly so. The principal difference appears to be in the solubility of lime and silica in these two soils. Our studies indicate these factors to be closely related to the assimilation of phosphoric acid. This is further indicated by the fact that there was only a very slight increase in the P_2O_5 content of the juice on the fertilized plots.

Potash. Similar studies as published in the Record, also at Pioneer Mill, have shown quite a consistent relation between the potash in the juice and availability. However, with this element there appears to be a greater relative increase in assimilation on the fertilized plots. This would indicate a lesser influence of outside factors on the assimilation of potash. It is suggested from the results obtained at Pioneer Mill that a cane juice containing less than .05% K_2O indicates the need of potash fertilization, and one containing .10% does not. At the Experiment Station we have data also from Exp. 6, Oahu Sugar Co., and Exp. "V", Waipio, neither of which responds to potash. The juice from Waipio contained .12% K_2O while at Oahu it varied from .11 to .14%. From these experiments we failed to obtain any marked increase in the results from the potash fertilized plots. It amounted to only .01 to .02% as compared to .06% at Pioneer Mill and Olaa.

Soil Acidity

Attention has frequently been called to the acidity of Hawaiian soils which persists in spite of their basic character. For some time we have been studying the nature of soil acidity in Island soils with special reference to the role of iron, aluminum and manganese in governing this reaction and the role which they play in the fertility of the sugar lands. The first phase of this work has progressed very satisfactorily and produced some very interesting results.

Qualitative Tests for Acidity. A comparative study of a number of the qualitative tests for soil acidity produced three which appear to be well adapted to our soils. These include the litmus, Veitch and Comber methods. The latter method, involving the use of potassium sulphocyanate, being a new one, it may be well worth while to describe in some detail. Potassium sulphocyanate is extensively used in qualitative analysis as a test for ferric iron. Soluble forms of iron, aluminum and manganese are present in most acid soils, the higher the acidity the greater the amounts present. Comber found that on shaking an acid soil with the above reagent a red color developed while a colorless solution appears with alkaline soils. The delicacy of the test depends upon the solvent used and the most suitable form which we have found is a commercial article sold under the trade name "Rich or Poor."

Quantitative Tests. A study of all the well known methods of quantitatively determining soil acidity or lime requirement produced a most bewildering array of results. These have been published recently in the Record, so suffice it to say that the Veitch is as good as any. A determination of the solubility of lime in water saturated with carbon dioxide agreed very closely with the reaction of the soil and did so consistently. The latter method shows very clearly the definite association of lime with the reaction of our soils and indicates that further value might be attached to this method on more extensive application. It is at least the most promising, other than the hydrogen ion determination by the hydrogen electrode or colorometric methods.

Nature of Acidity. Results obtained thus far indicate aluminum salts and alumino-silicates to be the principal factors associated with the acidity of our soils. These compounds are present in most soluble forms in the soils from the humid districts such as the Hamakua Coast and the upland areas on the other

Islands. Acid-reacting organic matter also appears to be a factor in the solubility or activity of these compounds. In the lowland districts these factors are strongly involved in the acidity of poorly aerated areas. In the poorly aerated soils there is usually found a greater solubility of iron and manganese. Iron appears to be a factor only in the very acid soils, while a low acidity appears to be typical of the manganese soils. Both the latter play a secondary role to aluminum. Our studies indicate further that the availability of iron in the manganese soils is just as great as in the non-manganiferous soils of equal acidity but that solubility of iron and acidity run hand in hand.

Relation to Fertility. Since Abbot, Conner and Smalley, at the Indiana Experiment Station published results in 1913 showing the relation of low root vitality in corn with soil acidity, which latter they attributed to the presence of hydrolysible salts of aluminum, considerable attention has been given to the influence of this factor in soil fertility problems. A review of this work is obviously outside the scope of this report. Suffice it to say that aluminum salts themselves have been shown to be toxic toward certain plants as well as being associated with acid reacting soils. As stated above, our studies have shown aluminum salts to be one of the principal factors involved in the acidity of our soils. Also the prescence of soluble aluminum salts has been noted. The logical question arises as to the association of inhibited root development of sugar cane, as well as pineapples, with this soil condition. The progress of this phase of the work has not developed sufficiently to draw definite conclusions but it may not be amiss to cite certain observations.

At the Rhode Island Experiment Station, where a method has been worked out for determining the so-called "active" aluminum in soils, those containing more than 225 parts per million were found to be associated with low root vitality when cropped to plants toward which aluminum salts are known to be toxic. With few exceptions acid Hawaiian soils are above this figure and several upland fields where root vitality is low have shown considerably higher aluminum content as determined by the above method. The Hamakua coast soils where Lahaina first failed, are uniformly high in soluble forms of aluminum. Also the high organic and moisture content of these soils are conditions which have been found to be associated with a greater solubility of aluminum. The pineapple lands, also being upland areas are likewise located in such an environment. Evidence is therefore not lacking, indicating the low vitality of sugar cane and pineapples in some districts, to be associated with toxic amounts of aluminum salts. This is further indicated by the almost universal response of upland soils to phosphate fertilization, low phosphate availability being usually associated with the presence of soluble aluminum salts.

As for the toxicity of aluminum salts toward sugar cane, in water and sand cultures we find aluminum sulphate shows considerable toxicity and preliminary investigations indicate less resistance in the Lahaina variety.

Chemical methods of determining toxic amounts of aluminum in our soils have not thus far produced any very encouraging results. Like the application of many analytical methods to our soils, this factor will probably require some study before we are able to actually prove or disprove the presence of toxic

amounts of aluminum. This in spite of the fact that we are able to definitely show its presence.

The principal corrective agents for such soil conditions are liming and heavy phosphate applications. To date, pot experiments on a soil from a field at Honokaa where even D 1135 showed indications of root-rot, have responded markedly to heavy phosphate applications using Lahaina seed.

Report of the Committee on Phosphoric Acid and Potash Determinations in Cane Juices*

By J. H. Pratt

The determination of potash and phosphoric acid in crusher juice as an aid in finding the fertilizer requirements of the different fields was suggested by H. S. Walker in the Planters' Record, Vol. 26, pages 317-321, and Vol. 27, pages 112-115. During the past year this has been made part of the regular laboratory routine at Ewa and Pioneer Mill and preliminary work has been done at several other plantations. As over two thousand determinations have been made, enough data has been accumulated to enable us to draw some very interesting conclusions and comparisons. Some of these are, perhaps, little more than surmises and subsequent work may disprove them; others, however, have enough confirmation to seem definitely proven. It should be remembered that these are based on only *one* year's work on only *two* plantations. Conditions at Ewa and Pioneer Mill are obviously dissimilar with regard to soil, cane, and water conditions and it is interesting, therefore, to see in how many cases the same conclusions have been reached.

The methods of analysis, as given in the Planters' Record have been followed, except that the results have been calculated on the basis of "per 100 solids (Brix) in juice" rather than on "grams per 100 c.c. of juice." The potash figures from Ewa are given on basis of "grams per 100 grams of juice," otherwise, except where noted, all figures for both P_2O_5 and K_2O are given on the new basis. This is felt, by both W. P. Alexander and the writer, to be a more logical method of comparison, as the density of the juice may vary considerably at different seasons of the year, altho as Mr. Alexander says, "If the data were available, percent on the weight of the ash would be still more accurate."

Effect of Location of the Field on Potash and Phosphoric Acid

At Ewa, the fields which yield a juice with low potash content are, with two exceptions, concentrated in a very definite area—the very heavy soils above the mill site—and they find that a lack of potash in the soil (with the corresponding deficiency in the juice) is related in many instances to poorly drained areas. The fields below the mill, which are irrigated with mill waste water often containing mudpress cake and molasses, and the makai fields in the Waimanalo section are

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Chart I

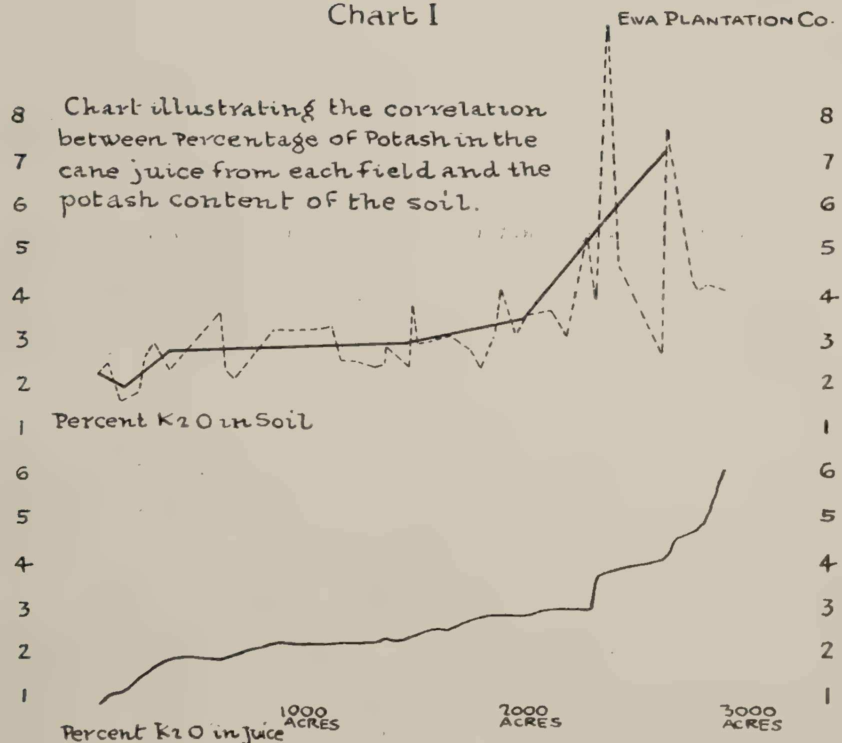
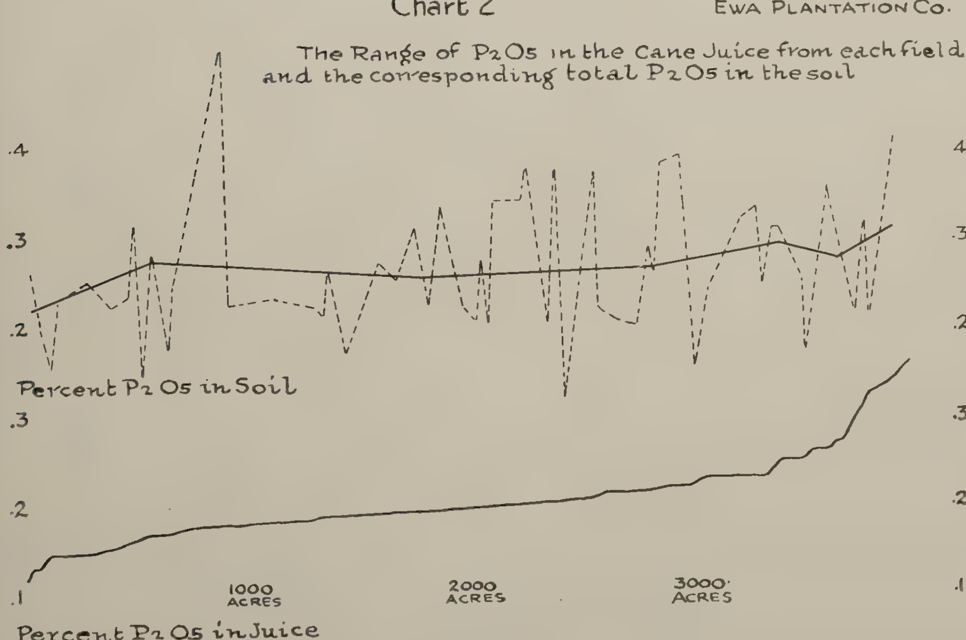


Chart 2



the highest in potash. Those lowest in P_2O_5 are scattered from one end of the plantation to the other, being the highest fields in the Waimanalo section and the lowest in the Honouliuli section. There seems to be some evidence that cane grown on land "made" rather recently from the deposit of storm waters, gives a juice low in P_2O_5. This is in spite of an excellent growth on all these so-called "waste ditch soils."

At both Oahu and Pioneer Mill, where there is a considerable difference in the elevation between the high and the low fields, the elevation is a most important factor. H. W. Robbins says, "Our results show a fairly regular drop in P_2O_5 from fields at a lower elevation to those at a higher elevation, and a very marked difference between extreme low and high elevations." That the same is true at Pioneer Mill is shown by the following averages for our main groups of fields:

Table No. 1

Field	Elevation Approximate	P_2O_5 Samples	P_2O_5 %	K_2O Samples	K_2O %
A	900′–1250′	10	.051	4	.827
B	350 – 900	60	.071	50	.902
C	75 – 350	37	.115	29	2.055
D	below – 75	23	.214	19	1.679
E	900 –1900	15	.053	12	.798
F	550 – 900	30	.052	28	.789
G	400 – 550	18	.058	17	.562
H	200 – 400	29	.098	25	1.640
I	below – 200	14	.212	6	1.864
LA	525 –1450	31	.066	31	.684
LB	275 – 525	39	.113	36	.875
LC	100 – 275	48	.191	46	1.494
LD	75 – 100	24	.188	23	1.774
O	below – 75	55	.233	48	1.840
MA	350 – 800	6	.074	..	....
MB	250 – 350	13	.115	13	1.002
MC	100 – 250	10	.202	5	1.767
MD	below – 100	8	.209	4	2.032
30-34	up to – 700	51	.050	46	1.288

These groups of fields are in long narrow strips running more or less horizontally, with the upper and lower boundaries usually following the contour, and on the average two miles long by from one-fourth to one mile wide. In the Honokawai section (Fields 30 to 34) where the fields run the other way—from mauka to makai—the samples from the bottom of the field were much higher in both potash and P_2O_5 than those from the middle of the field, while those from the upper end were still lower.

Comparison Bewteen Soil and Juice Analyses

At Pioneer Mill we are fortunate in having about forty soil analyses of recent date and representing almost all of our principal groups of fields. In the following comparison, the figures have been arbitrarily divided into four classes in the case of P_2O_5, and five classes in the case of the potash, which classes for the sake of convenience have been called "high", "good", "intermediate", "fair" and "low".

Table No. 2.

P_2O_5.

Crusher Range	Juice Fields	Citrate Range	Sol. x 10 Fields	HCl Range	Soluble Fields	Total Range	Fields
.0 - .06	A, E, F, G, 30	.00-.05	A, E, F, G, 30, B, H, MB	.00- .9	F, G, LA, LB	.1½-.2½	E, F, MB
.07- .12	C, LA, LB, B, H, MB	.05-.10	C, LA, LB, I, MC	1.0 -1.2	E, H, MB, 30	.2½-.3	G, H, MB, MD, LA, LD, 30
.13- .18	None	.10-.15	None	1.3 -1.5	B, C, D, I, MC	.3 -.3½	B, C, D, I, MC
.19- .24	O, LD, MD, D, I, MC	.15 up	D, LD, MD, O	1.6 up	A, LD, O, MD	.3½ up	A, O
			Potash				
.0 - .7	G, LA	.0 -.2	G	.0 - .15	F, LA	.0 -.3	F, G, LA, LB, MC
.7 -1.0	A, B, E, F, LB, MB	.2 -.3	E, F, H, MC, 30	.16- .2	A, C, D, E, O, LB, MC	.3 -.4	D, E, O, LD, MB, MD
1.0 -1.5	30	.3 -.4	A, C, I, O, LA, LD	.21- .26	G, LD	.4 -.5	C, H, I
1.5 -1.8	D, LD, MC	.4 -.5	B, D, LB	.26- .30	H, I	.5 -.6	A
1.8 -2.5	C, H, I, O, MD	.5 up	MB, MD	.31 up	B, MB, MD, 30	.6 up	B, 30

Table No. 3—Classification of Fields

	P_2O_5					K_2O				
Field	Juice	Citrate	HCl	Sol. Total	Ave.	Juice	Citrate	HCl	Sol. Total	Ave.
A	low	low	high	high	low	fair	int.	fair	good	int.
B	int.	low	good	good	int.	fair	good	high	high	?
C	int.	int.	good	good	int.	high	int.	fair	int.	
D	high	high	good	good	high (—)	good	good	fair	fair	good(—)
E	low	low	int.	low	low	fair	fair	fair	fair	fair
F	low	low	low	low	low	fair	fair	low	low	fair(—)
G	low	low	low	int.	low	low	low	int.	low	low
H	int.	low	int.	int.	int.	high	fair	good	int.	?
I	high	int.	good	good	good	high	int.	good	int.	int.
LA	int.	int.	low	int.	int.	low	int.	low	low	low
LB	int.	int.	low	int.	int.	fair	good	fair	low	fair
LD	high	high	high	int.	high	good	int.	int.	fair	int.
O	high	high	high	high	high	high	int.	fair	fair	?
MB	int.	low	int.	low	low-int.	fair	high	high	fair	fair-high
MC	high	int.	good	good	good	good	fair	fair	low	fair
MD	high	high	high	int.	high	high	high	high	fair	high
30-34	low	low	int.	int.	low-int.	int.	fair	high	high	?

In the case of the P_2O_5, there is a fairly close agreement between the crusher juice and citrate soluble classifications; twelve of the fields fall into the same classification and three of the other five into the next class.

With the exception of the "A" fields, there is also a fair agreement between the juice analysis and the "HCl soluble," and also the total P_2O_5. With the potash, the agreement is not so close. Some of the fields check very well, but others are considerably off. It should be remembered that in many cases there is only one soil sample from a group and that the juice may have come from cane at a considerable distance from the place where the soil sample was taken.

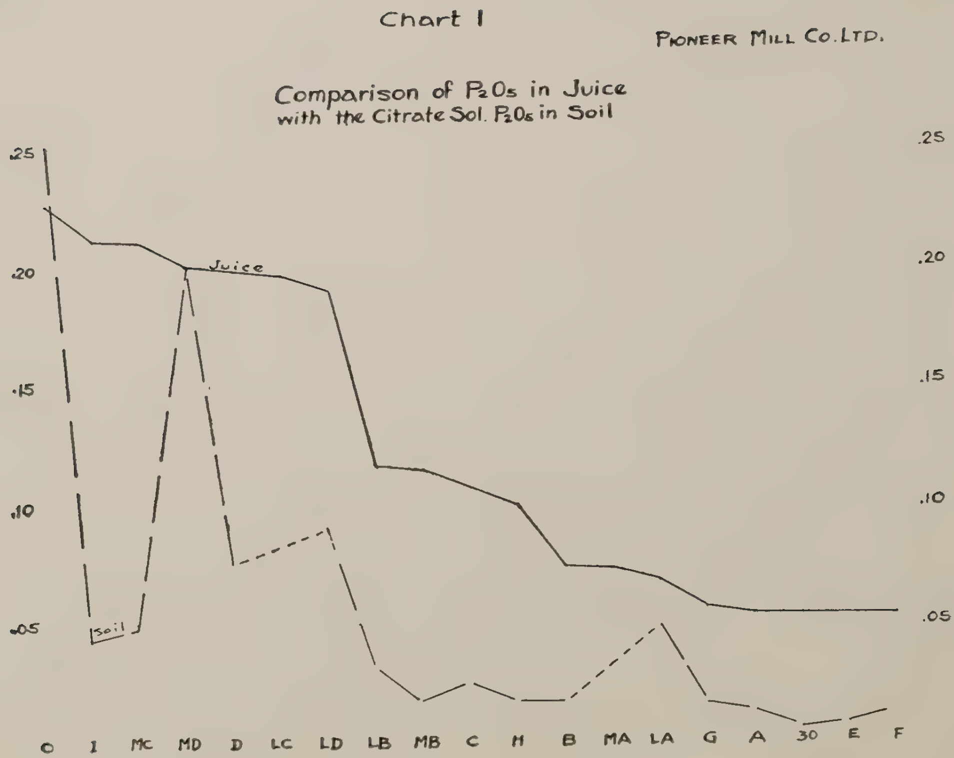


Chart I
Pioneer Mill Co. Ltd.
Comparison of P_2O_5 in Juice with the Citrate Sol. P_2O_5 in Soil
.25
.20
.15
.10
.05
Juice
Soil
O 1 Mc MD D LC LD LB MB C H B MA LA G A 30 E F

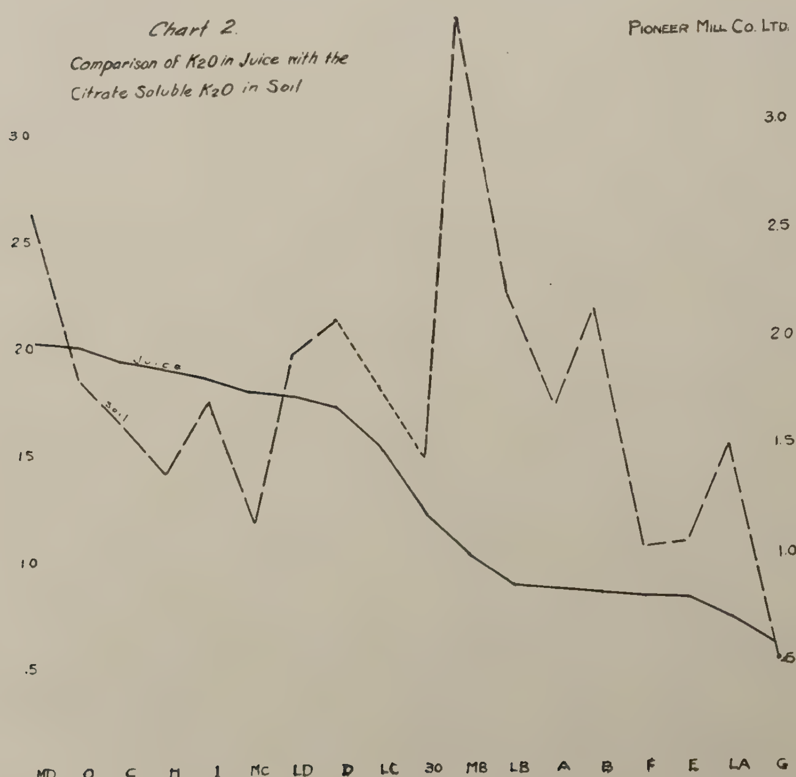


Chart 2.
Pioneer Mill Co. Ltd.
Comparison of K_2O in Juice with the Citrate Soluble K_2O in Soil
3.0
2.5
2.0
1.5
1.0
.5
Juice
Soil
MD O C H 1 Mc LD D LC 30 MB LB A B F E LA G

An interesting point in this connection is, that the "G" fields are the lowest in potash of any fields on the plantation both in soil analysis and in the juice determinations, altho, judging from their location, they should be higher than the "F" and "E" fields.

At Ewa, Mr. Alexander finds that the percentage of potash in the juice is related to both the soil analysis and the need of the cane for potash. Chart 1 brings out clearly that the percentage of potash in the juice is directly correlated with the amount of potash present in the soil. There is a variation in soil analyses from field to field, but the averages show a steady climb as the amount of potash in the juice increased. In regard to P_2O_5, he says, "The number of soils analyzed recently is not sufficient to draw conclusions as to the possible correlation between the amount of phosphoric acid in the soil and that percentage which appears in the juice." Using some total P_2O_5 (HCl digestion) determinations made at Ewa over twelve years ago in combination with a few of the more recent analyses made by the plantation, one sees that while there is a tendency for the phosphoric acid in the juice and soil to parallel each other, the individual variations are so great that the data are hardly indicative of what seems true for potash. It is possible that the citric acid soluble P_2O_5 would offer a better means of comparison.

Yield per Acre and Quality of the Juice

There is no direct relationship between the percentages of potash and phosphoric acid and either the tons of cane per acre or the tons of sugar per acre; some of the individual fields which are lowest in one or both of these ingredients yielded twenty tons of cane per acre more than the average. The following table shows that there is a tendency for the high P_2O_5 fields to have a higher yield than those which are lower in P_2O_5, but the same does not seem to hold true for potash:

Table No. 4

	P_2O_5				K_2O			
	Fields	TC/A	TS/A	TC/TS	Fields	TC/A	TS/A	TC/TS
High	16	61.39	7.02	8.75	31	57.56	6.52	8.83
Good	25	54.13	6.55	8.26	16	51.25	6.13	8.36
Intermediate	..	....	...	...	15	54.54	6.81	8.01
Fair	37	51.82	6.54	7.93	24	51.72	6.75	7.66
Low	18	51.47	6.85	7.51	10	54.09	7.23	7.48

It is interesting to note the steady increase in the TC/TS as the potash and phosphoric acid increased.

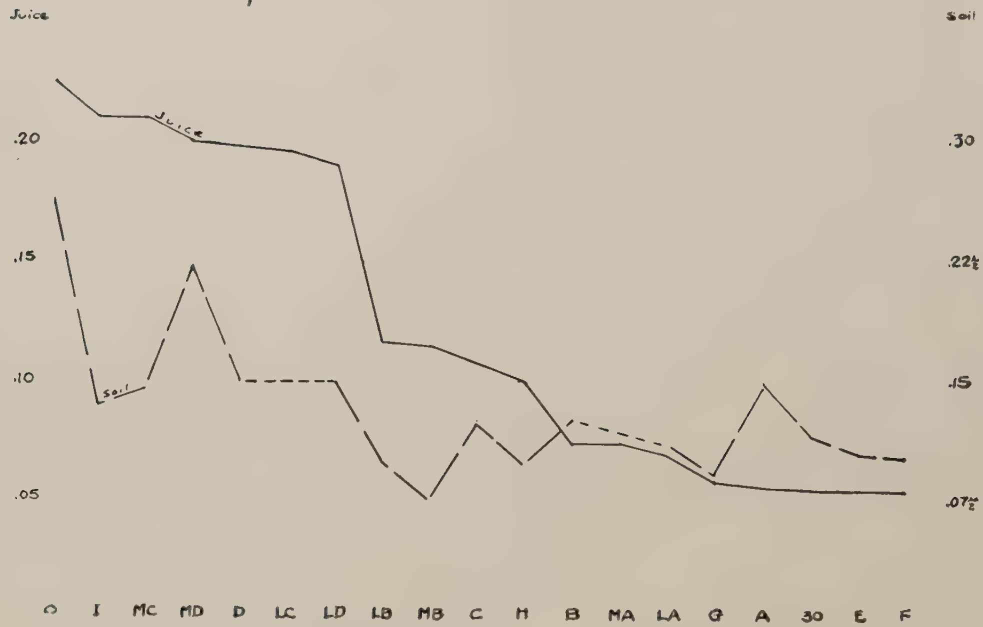
Effect of Adding K_2O and P_2O_5 to the Soil

Mr. Alexander finds at Ewa that, "Phosphate fertilizers do not act so as to increase the P_2O_5 content of the juice. There is definite proof of this contention." The average of a number of tests at Ewa show .0380 grams of P_2O_5 per 100 c.c. of juice from the plots which received 100 lbs. to 200 lbs. of P_2O_5, against an average of .0379 for the check plots. We have also found the same to be true at Pioneer Mill and several examples are given in Table No. 5.

Pioneer Mill Co. Ltd.

Chart 3

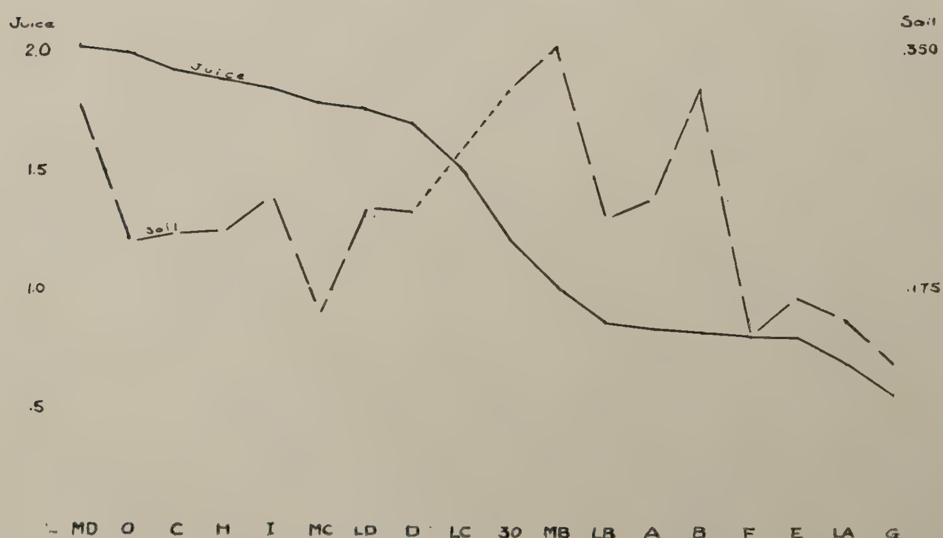
Comparison of P_2O_5 in Juice and Soil



Pioneer Mill Co. Ltd.

Chart 4

Comparison of K_2O in Juice and Soil



With regard to potash at Ewa, they find that, "The data secured is very inconclusive." In some cases there was a small increase, in others a decrease.

At Pioneer Mill, with the exception of an experiment in field B6, we have found a small but definite gain of K_2O in the juice from potash fertilization. The same was also found in a potash experiment at Olaa, several sticks from each of thirty-two plots being sent to Lahaina for analysis.

TABLE No. 5

Potash and P_2O_5 Experiment

	% P_2O_5	% K_2O	Treatment
Field B6....	.055	1.057	None
St. Mex......	.057½	.833	100 lbs. each
	.054	1.029	100 lbs. K_2O
	.053	.960	100 lbs. P_2O_5

P_2O_5 Experiment

	% P_2O_5	% K_2O	Treatment
Field B6	.062	.949	None
St. Mex......	.058	.937	375 lbs. P_2O_5
	.062	1.069	625 lbs. P_2O_5
	.057	.793	875 lbs. P_2O_5

K_2O and P_2O_5 Experiment

	% P_2O_5	% K_2O	Treatment
Field 31.....	.006	.363	None
H 109	.006	.398	100 lbs. P_2O_5, 50 lbs. K_2O

K_2O and P_2O_5 Experiment

	% P_2O_5	% K_2O	Treatment
Field B2....	.003	.690	None
H 109.......	.003	.741	50 lbs. P_2O_5, 100 lbs. K_2O

POTASH EXPERIMENT AT OLAA

K_2O	% K_2O									Ave. %
None	.243	.355	.194	.189	.192	.156	.287	....	....	.231
100 lbs.	.493	.335	.376	.236	.313	.232	.297	.332	.511	.347
150 lbs.	.434	.553	.367	.355	.368	.289	.314	.528	....	.401
200 lbs.	.582	.419	.603	.381	.468	.424	.547	.439	....	.483

The experiments from field B6, were sampled at the mill in car load lots and analysed in duplicate. The experiments in 31 and B2 not being quite mature, two sticks were taken from each plot and ground in a hand mill. Five repetitions in 31 and four in B2 were each analysed in duplicate or triplicate. The potash determinations on the cane from Olaa were made in triplicate. The results are, therefore, accurate. A small observation test has been started at Pioneer Mill in a field very low in both potash and phosphoric acid, in which these ingredients have been applied in various forms in very heavy doses to small areas.

EFFECT OF VARIETY OF CANE

So far, we have been unable to establish any regular difference in potash and phosphoric acid between the different varieties of cane. Any such difference that may exist is not sufficient to overcome local soil variations. Comparing the different fields at Pioneer Mill, H 109 averages higher (.126 against .117) than Lahaina in P_2O_5, and also in potash (1.322 against 1.117). H 109 is also slightly higher than Striped Mexican in P_2O_5 (.119 against .109), but about the same in K_2O (1.282 against 1.286). H 109 is lower than D 1135, both in P_2O_5 (.130 against .135) and in K_2O (1.341 against 1.661). At Ewa where Lahaina cane had been replanted with both D 1135 and H 109, it was possible to obtain samples

Chart 5

Pioneer Mill Co. Ltd.

Comparison of P_2O_5 in Juice with the HCL Sol. P_2O_5 in Soil

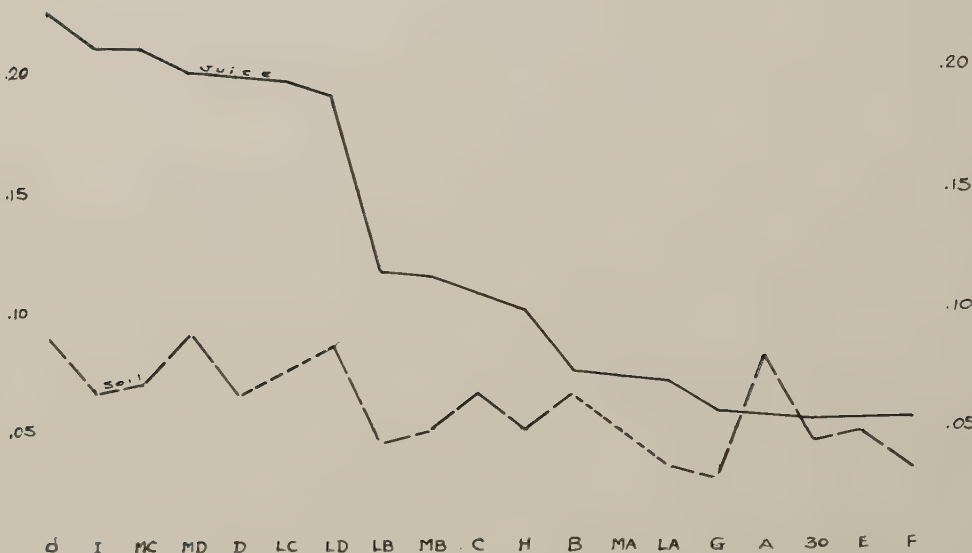
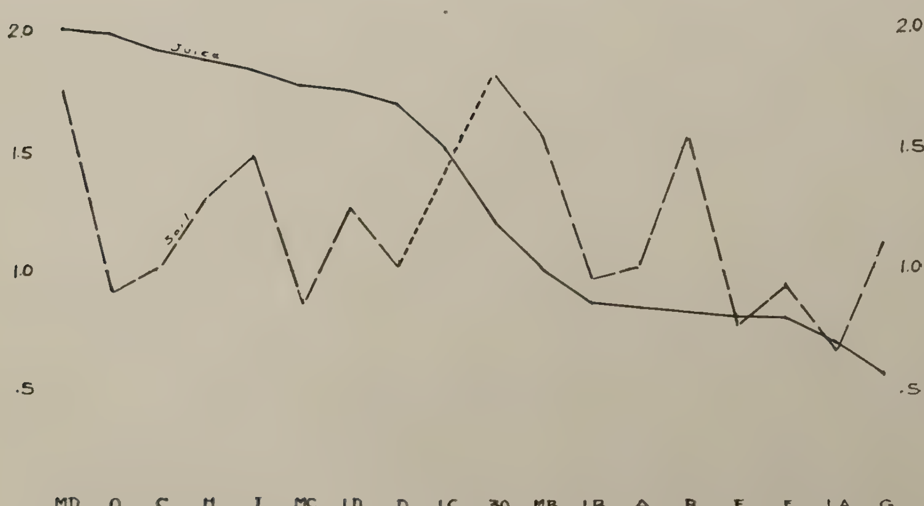


Chart 6

Pioneer Mill Co. Ltd.

Comparison of K_2O in Juice with the HCL Soluble K_2O in Soil



of these three varieties from less than five running feet of line. These gave D 1135 .020 grams P_2O_5 per 100 c.c., H 109 .014, and Lahaina .011. In another field, H 109 showed .319 and Yellow Caledonia .280%. Similar small samples from fields at Pioneer Mill showed:

Field 34 Plant	Lahaina	St. Mex.	D 1135	H 5919	H 456	H 109	Red Seedling
P_2O_5	.005	.004	.005	.004	.004	.004	.005
K_2O	.238	.268	.315	.231	.310	.151	.180

Field LB-2	St. Mex.	H 5919	H 456
P_2O_5	.010½	.009½	.010½
K_2O	.155	.204	.140

Field K-1	St. Mex.	H 109
P_2O_5	.152	.168
K_2O	.698	.608

Field O 7	Yellow Cal.	Rose Bamboo	Lahaina	St. Mexican
P_2O_5	.061	.049½	.051	.039
K_2O	.383	.313	.222	.187

The above figures, except those from field K-1, are on the basis of grams per 100 c.c. of juice.

Effect of Time of Cutting

Results from the main groups of fields at Pioneer Mill seem to indicate that there is a tendency for the percentages of potash and phosphoric acid to vary with the time of cutting, being highest in P_2O_5 in February or March and highest in K_2O in December. The results from the different groups of fields are fairly consistent; February, for instance, being higher in P_2O_5 than the other months in 34 out of 45 comparisons.

	December	January	February	March	April	May
P_2O_5	.105	.115	.136	.135	.129	.113
K_2O	1.704	1.544	1.161	1.237	1.093	1.050

The age of the cane also has an effect on the percentage of K_2O and P_2O_5 as shown by the following analyses. In all the eight cases given below, the "suckers" were higher in both K_2O and P_2O_5 than primary sticks from the same stool. The first four samples were from H 109 cane twelve months old, the next two from H 109 cane sixteen months old, the last two from Striped Mexican of the same age.

	Old Sticks % P_2O_5	Old Sticks % K_2O	Suckers % P_2O_5	Suckers % K_2O
Field O-2 H 109 cane	.174	1.492	.254	2.706
do	.156	1.288	.221	2.144
do	.170	1.492	.317	4.247
do	.161	1.411	.238	2.326
Field K-1 H 109 cane	.212	0.652	.314	2.709
do	.123½	0.564	.171	1.450
do Str. Mexican	.157	0.719	.165	2.028
do	.148½	0.676	.217	2.006
Average	.163	1.037	.237	2.452

Plant vs. Ratoons

There also seems to be a tendency for the plant cane to be lower in both P_2O_5 and K_2O than the ratoon cane at Pioneer Mill. The average for the entire plantation and for each of the four sections gave lower results for plant than ratoons. In fourteen out of twenty-one cases in which both plant and ratoon cane was growing in the same or adjoining fields, the ratoon cane was the higher in both potash and phosphoric acid. The averages were .103 % P_2O_5 for plant and .112 for ratoons, and 1.122 % K_2O for plant and 1.296 for ratoons. This difference is perhaps too slight to be very conclusive.

Long ratoons are lower in P_2O_5 and higher in K_2O than short ratoons in six out of eight comparisons. The averages are long ratoons .194 % P_2O_5, short .214%, long ratoons 1.740 % K_2O and short 1.410.

Content of Different Parts of Stalk

In a test of 12 mature stalks of cane divided into thirds and ground in a hand mill, Alexander finds:

Top of stick	.0800 % P_2O_5	.063 % K_2O
Middle of stick	.0864 "	.042 "
Butt of stick	.1138 "	.010 "

Variation Within a Field

While the averages for the different fields are consistent, the individual samples from some of the fields may show considerable variation. Mr. Alexander finds that at Ewa, "The more uniform the contour and type of soil, the smaller the individual range between the individual samples of the juice," and he concludes, that it is necessary to obtain six samples from each field to insure an accurate average. The following figures show the variation in some of the Ewa fields:

Field	Area	No. of Samples	Percent K_2O in the Juice Average	High	Low
20-A	53.48	11	.101	.165	.055
11	58.30	6	.104	.177	.019
14-B	76.84	7	.144	.217	.073
15-B	126.06	9	.214	.352	.092
2-A	105.75	8	.214	.372	.115
28-A	146.25	7	.248	.352	.192

Very few of the fields at Pioneer Mill show anywhere near this amount of variation in the potash, and the amount of variation in the phosphoric acid is considerably less. On the other hand, some of the fields run remarkably consistent to the average. Five samples from LB5P, for example, showed .092, .098, .097, .094 and .094 % P_2O_5, one of the samples was from cane ground in December and the other four from cane ground in March. The three samples from O 11L gave .267, .267, and .267 % P_2O_5 and 1.91, 1.89, and 1.90 % K_2O. The amount of variation between stools is shown by the figures given above to show the difference between "suckers" and primary sticks; the four stools in O-2 being

Chart 7

PIONEER MILL CO. LTD.

Comparison of P_2O_5 in Juice
with the
Total Sol. P_2O_5 in Soil

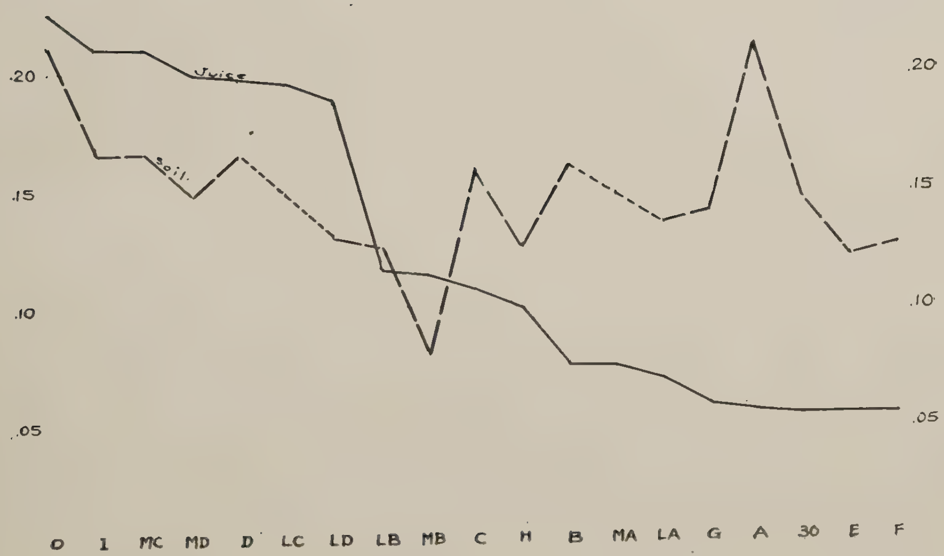
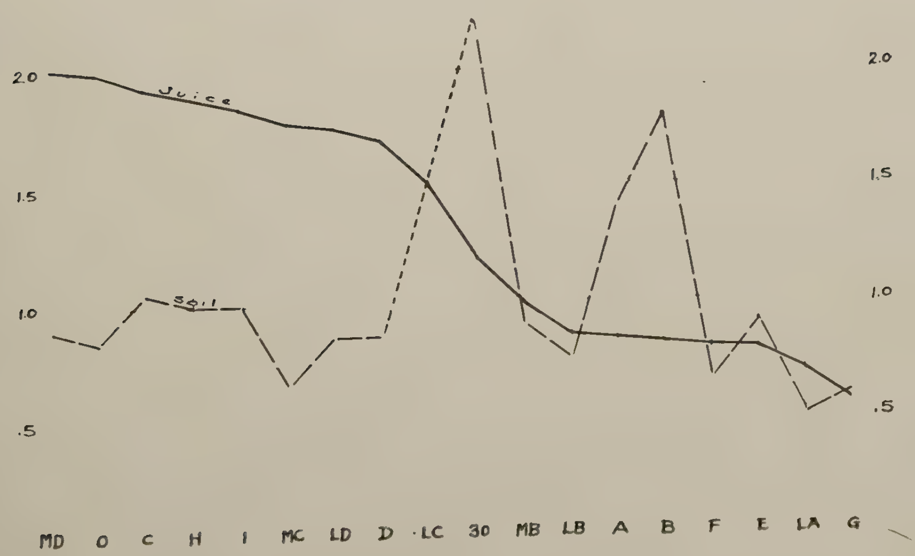


Chart 8

PIONEER MILL CO. LTD.

Comparison of K_2O in Juice with the
Total Soluble K_2O in Soil.



located very near each other, the first H 109 and first Striped Mexican stools being adjoining, and the same being true of the second H 109 and Striped Mexican stools.

Accuracy of Method of Analysis

The following duplicates made on the same samples at different times show the degree of accuracy of the Sherrill method. The results are calculated on the basis of "% on weight of juice" and none of the samples were concentrated.

Yellow Caledonia	.379 &	.386	Rose Bamboo	.312 &	.313
Lahaina	.219	.225	St. Mexican	.175	.199
Lahaina	.235	.240	H 109	.151	.151
Field C-10	.249	.252	St. Mexican	.267	.269
D 1135	.309	.321	H 456	.307	.312
Red Seedling	.174	.186	H 5919	.228	.233

Average of 12 trials, low sample .252, high sample .259, difference .007. Another set all made on Yellow Caledonia cane shows about the same degree of accuracy:

1	.052	.051½	.048½	....	....	17	.088½	.088½	......
2	.074	.074	.080	....	....	18	.115½	.115½	......
3	.046 / .034	.044 / .048	.040	.040	.042	19	.077	.079	.084½
4	.038½	.037	....	....	....	20	.063	.061	......
5	.043	.044	.033	.044	....	21	.081	.075	.074½
6	.029½	.031½	.034	....	....	22	.074	.074	......
7	.058	.056	.054	.067	.066	23	.063½	.066	.069
8	.068	.071	.062	....	....	24	.113	.113	.111½
9	.046½	.047½	....	....	....	25	.083½	.080	.075
10	.063	.062	.062	....	....	26	.100	.097	.093½
11	.070	.070	.067	....	....	27	.087	.090	.090
12	.111	.112	.112	....	....	28	.091	.096	.092½
13	.109	.101	.098	....	....	29	.106	.108	.102
14	.072	.072	....	....	....	30	.128½	.126	......
15	.081	.083	.077	....	....	31	.091	.091	......
16	.052	.052	.050	....	....	32	.131½	.130	......

The phosphoric acid method is even more accurate. During the year a few samples were encountered which gave some difficulty. These were all either from Yellow Caledonia cane or from a field which was exceptionally low in P_2O_5. Any person familiar with the method and using proper care should get results checking within .001 or .002 grams P_2O_5 per 100 c.c. and it is easily possible to get closer than this if necessary.

Conclusions

1. The methods of analysis for potash and phosphoric acid are simple and easily made part of the laboratory routine.

2. There is considerable variation in the P_2O_5 and K_2O content of the crusher juice depending upon the location of the field.

3. There is a correlation between the juice and soil analyses.

4. There seems to be a tendency for fields having high percentages of P_2O_5 in the juice to have a higher yield of cane, altho this is by no means proven. There is also a tendency for cane high in K_2O and P_2O_5 to have a higher quality ratio.

5. Adding phosphate fertilizers does not increase the P_2O_5 content of the juice, but adding potash fertilizers does increase the percentage of K_2O.

6. There is not much difference between H 109, Lahaina, and Striped Mexican in the P_2O_5 and K_2O content, but D 1135 seems to be slightly higher.

7. There seems to be a slight difference in the percent of K_2O and P_2O_5 in the juice at different times of the year.

8. Plant and ratoon cane may have different percentages of K_2O and P_2O_5, plant cane being the lower. This difference is too small to be conclusive. There is a larger difference betwen long and short ratoons.

9. The upper end of the stick contains the largest amount of K_2O and the smallest amount of P_2O_5.

10. There is considerable variation between the different samples in some fields, while others run very uniformly. This is dependent on the contour and the variation of the soil.

The practical application of this comprehensive collection of data is to decide whether the determination of potash and phosphoric acid in the cane juice offers a reliable source of information as to the available supply of these elements in the soil.

If the data obtained is found to be trustworthy, another link has been added to the chain of evidence which gives us a better understanding of the forms of fertilizer it is best and necessary to apply.

While the results secured during 1923 for one crop are, therefore, preliminary, certain correlations have been made which give this first year's work real value.

In conclusion I wish to express my thanks to Mr. H .E. Starratt, Mr. H. W. Robbins, and especially to Mr. W. P. Alexander, much of whose report on this subject has been copied verbatim.

Report of the Committee on Cultivation and Weed Control*

By H. E. Starratt

Cultivation and weed control in the sugar cane industry is of less importance on the irrigated than on the unirrigated plantations. On the former, the artificial application of water, with abundance of sunshine, forces the cane into such rapid growth that the weeds are smothered out, thus eliminating the necessity for weed control. On the unirrigated plantations the high percent of cloudy days, with excessive rainfall, 100 to 300 inches per annum, causes a slow growth of cane; so the shading out of weeds does not take place at such an early date. In order to control the weeds, artificial means have to be resorted to.

Cultural operations for weed control on the irrigated plantations are of minor consideration. Most of the cultivation done is in preparation for planting. This article deals more especially with cultivation in preparation for planting and weed control on unirrigated plantations.

Owing to labor difficulties, and the necessity for lessened cost of production, all of the operations could not be performed, so experiments were conducted to determine their value in cane production. Conclusive tests have not yet been conducted in all of the operations, however, experiments that have been made will be given when they are at hand, in following through the procedure.

Plant Cane

Preparing for Planting: The seed bed, by popular opinion, should be the best that implements can make. In recent years, modern appliances, the tractor, types of plows, subsoilers, harrows, and cultivators, have been introduced to the field with apparent good results. These are improvements over the slow mule drawn implements, as the element of speed helps greatly to pull up the old cane stools and pulverize the soil.

Burning: The first operation, after harvesting a field that is to be planted, is usually to burn all of the refuse, but now with a well sharpened disc plow even a moderate amount of trash may be turned back to the soil when the old stools are plowed out.

Plowing: The irregularities of the fields of the unirrigated plantations do not permit the use of the steam plow that is used so successfully on irrigated plantations. Formerly, on the former plantations, implements were drawn by mule power, but now tractors greatly facilitate the field work. With these, new types of plows have been introduced. The most notable of these has been the adoption of the disc plow in preference to the mould board.

Harrowing: Following a period of weathering, the field is harrowed with a modern Kilifer harrow, tractor drawn, or with the old heavy frame tooth harrow.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Subsoiling: If there is a depth of soil, there is an inplement that reaches down 18″ to 24″ and breaks up any hardpan or packed earth and opens up new areas for drainage and root extension. This implement, the Kilifer Subsoil Plow, does not turn the soil over, but by the use of a vertical bar with a short cross arm simply breaks up the subsoil without bringing it to the surface.

Lime: Where it is a practice to lime the fields it may be done just before the second plowing. There is no fixed amount or kind of lime used, but a popular practice is to add 8 to 10 barrels of ground Waianae lime per acre. The application may be up to a ton of hydrated lime per acre, or caustic lime may be added in lesser amounts. Several years ago successful experiments were conducted with the application of coral sand at the rate of two to four tons per acre.

Lime Experiments—Hamakua Mill Company: "No well defined gains are shown from the residual effects of lime applications at Hamakua Mill Co. In these experiments, reported two years ago, liming failed to show to advantage. The plots were again harvested in 1920, without further treatment, to determine if there was any after benefit. The yields are summarized as follows:

	Cane	Sugar
First Experiment		
Average all limed plots	26.7	3.53
Average all no lime plots	26.5	3.52
Second Experiment		
Average all limed plots	20.8	2.63
Average all no lime plots	19.2	2.43

"These experiments were conducted under drought conditions." [1]

A report of 1923 states, "A liming experiment at Kaiwiki Sugar Company showed no gain at all for the lime used." [2]

Lime does not act alone as a fertilizing agent, but when subsequent applications of nitrogenous fertilizers are applied, nitrification is accelerated, and where potash is a limiting factor of cane growth, there is higher availability in the presence of lime, so the gains where they occur might be due to the potash alone.

Coral Sand, 2 tons—Olaa 1911 and 1913 (Residual effect):

	Yield of Cane	
Fertilizer	Sand	No Sand
500	40.6	37.4
1000	51.6	47.0
1500	57.7	51.2

	Cane per Acre	
	1911	1913
Sand plats	49.9	44.7
No sand	45.9	40.5

Olaa soils respond to potash fertilization, so part of this gain may have been due to the liberated potash.

Lime carbonate causes the flocculation of clay, which renders the fine soil more penetrable for water, air, and plant roots, and more manageable for implement work.

Second Plowing: After liming or, if the practice has been discontinued, after harrowing or subsoiling, the field receives its second plowing. This may be done with a reversible disc plow, or any implement suitable for local conditions.

Furrowing: This operation was formerly, and still is on some plantations, done with a mule-drawn double mould board plow. Now tractors are employed which draw one or more.

Five feet is the popular spacing for rows, as this gives ample room for cultivation between them, and the cane closes in over the kuakuas sufficiently to smother weeds. At upper elevations where more upright canes are planted, and growth is slower, the rows are spaced four or four and one-half feet, to more quickly help weed control by shading.

Subsoiling: As a last resort for opening up the soil, plows go to a depth of 4″-12″ below the bottom of the furrow.

Planting: Variations of climatic conditions and soil call for different varieties of cane and different methods of planting.

Yellow Caledonia is still, by far, the most extensively cultivated cane on the lower elevations of Hawaii. According to a recent census the island had for a single crop 31,370 acres of Yellow Caledonia as compared to 7,873 acres of D 1135, its nearest competitor. Yellow Tip and Striped Tip have respectively 3,002 and 2,144 acres; the former is replacing the latter. H 109 is supplanting Yellow Caledonia on the irrigated lands of Paauhau and Honokaa. D 1135 is a cane of promise, as it is thought that by bud selection the smaller sticks can be eliminated in favor of a big stick strain.

Distance between seed pieces, their age (from 1 or 2-year cane) planting level or at an angle from butt to tip, entirely covered or not, is all a matter of local opinion, and conditions. In connection with bud selection work the writer took two seed pieces from 1-year-old cane, Caledonia, and of a possible 100% germination, 83.81% produced stools.

It is the practice in wet districts to incline the seed from butt to top, leaving the tip exposed, this prevents rotting before germinaion, and also prevents drying out, for if the lower eyes are 3″ under the soil there is little danger from drought.

A practice is to plant the seed pieces butt to butt making a continuous row of cane, but the writer has found that under rather adverse conditions 24,306 stalks per acre were produced with 1′ spacing, thus saving one-half of the seed.

Ratoon Cane

Palipali: This operation, performed by the man with the hoe, is necessary if a large amount of trash is left on the field after harvesting, or if the stools are left high by careless cutting. The operation consists of cutting any high cane stumps, and hoeing the trash from the cane row into the kuakua. The trash acts as a mulch, suppressing many of the upright weeds and grasses until the cane can get a good start, but it has been the writer's obesrvation that it is practically impossible to get rid of a growth of honohono which starts in the damp material and soon spreads everywhere. Without palipali (leaving the trash), you inevitably choose between a growth of honohono, or upright weeds and grasses. By burning after cutting, palipali is not necessary, and much honohono is done away with.

Off-barring Ratoons: Where level cultivation has been practiced, or with plant and first ratoons, this operation is not necessary. When the stool is older, however, it spreads outward, so it became a practice to cut away this new growth.

When performed, the operation is done with a 12″ to 14″ plow drawn along the outer edges of the stools, trimming them down to a square strip 10″ to 18″ broad and 4″ to 8″ deep; or a double disc plow, drawn by a tractor, cuts the stool perfectly, and a good share of soil is thrown into the kuakua, completely covering the weeds and trash.

Experiments indicate that off-barring reduces the yield of cane, but much can be said for the operation as a means of weed control. By covering, the trash is quickly rotted and the dirt thrown into the kuakua helps future implement work.

"An experiment at Hilo Sugar Company, comparing off-barring with the omission of the practice, resulted in 57 tons of cane per acre where off-barring was employed, against 59.4 tons where the practice was omitted. . . . "[3]

"*Off-barring, Plows, Hilling, Etc.:* In this test half of the plots were off-barred, plowed, hilled, etc. In the other half no plows were used, weeds were controlled by surface cultivators, hoeing, etc. . . . "

"The results follow:

Treatment	No. of Plots	Tons Cane per Acre 1919	Tons Cane per Acre 1923	Average Q. R.	Average Tons Sugar per Acre
No plows	9	56.2	55.4	7.99	6.98
Off-barring, plowing	9	55.6	51.7	8.02	6.70

. . . "The differences are not very great, and it would seem that on the whole, the matter resolves itself into the most efficient method of weed control with the least disturbance to the root system of the cane."[4]

"*Off-barring versus Not Off-barring:* In this test half of the plots were off-barred and the other half were not. All other operations were uniform to all plots. The results follow:

Treatment	No. of Plots	Tons Cane per Acre 1919	Tons Cane per Acre 1921	Tons Cane per Acre 1923	Average Q. R.	Average Tons Sugar per Acre
No off-barring	9	59.4	62.0	53.0	8.04	7.23
Off-barring	9	57.1	60.7	49.3	8.28	6.73

"These results show loss in sugar from off-barring."[4]

Stool Shaving: After a crop of plant cane is cut, new buds sprout from the base of the old cane stalk and from the surface, and underground part, of the old stool. As years go on this new tillering broadens the stool and raises it above its former level until it is perched high above the kuakua, with a mass of rotten roots below it. Growth to the sides is restricted by cultivating and hoeing, but the upward growth is hardly checked.

In order to lengthen the life of the stool and forestall the expensive operations connected with planting, a stool shaver was devised to cut off the butts of the old stalks, just below the ground surface. The implements were mechanically perfect and supplanted the heavy work of the operation of the palipali, and also doing much in the way of weed control, but the stools could not stand the treatment and by experiment reduced yields were experienced.

"*Stubble Shaving, Onomea, 1921 Crop:* The crop cane here was Yellow Caledonia, third ratoons long. With the exception of the stubble shaving, all

plots received similar treatment. The yields from the different treatments are given below:

No stubble shaving	41.5 tons cane per acre
Stubble shaved	41.6 tons cane per acre

"It must be borne in mind when judging the results of stubble shaving that a substantial saving is made in subsequent hoeing where stubble shaving is practiced, so even if no gain in yield results, it may still be a profitable practice." [5]

Stool Splitting: This operation of drawing a heavy implement fitted with a rolling coulter, to split the cane stools longitudinally through the middle and a subsoil plow to open up the area beneath the cane row was at first looked upon with great favor. It was thought that the opening of the stool would induce the buds on the lower part to mature, and the loosening of the soil beneath the row, a section of which with old ratoons was not disturbed at all, would create a greater root growth. The device was improved so that stool splitting, subsoiling, and off-barring could all be done in one operation.

At Hilo Sugar Co.—"Stool splitting and off-barring as compared to off-barring alone shows a loss of 2.84 tons of cane per acre. Stool splitting alone as compared to off-barring alone shows a difference of 3.30 tons of cane in favor of the off-barred plots." [6]

Cultivation: The Planet Jr. and Horner cultivators are the most popular implements for weed destruction between the cane rows. The former is usually passed three or four times along the kuakua, thus breaking down the weeds, uprooting them and scratching the soil to a depth of 2 or 3 inches. If burning has not been done after harvesting, the Planet Jr. insures more rapid decomposing of the trash by turning it over and mixing it with weeds and dirt.

After hoeing the cane rows, (hand work) the Horner Cultivator, or hapai harrow as it is locally called, drags the weeds into piles and covers them with earth. These piles, by the time the next hoeing is necessary, are quite rotted away. The Planet Jr. breaks down and spreads this decayed material.

The operations of cultivating, hoeing and harrowing, are repeated as often as conditions demand, to keep the fields free of weeds.

The Value of Weed Control: "In an experiment at Kilauea, weed control increased the cane yields by 7 or 8 tons of cane per acre, while fertilizing increased the yields about 9 tons of cane per acre. Clean culture with no fertilizing produced about as much cane as fertilizing without weed control." [7]

"*Cultivation—Regular Practice vs. Weed Control Only:* A comparison was made between regular plantation practice off-barring, middle breaking, hilling, etc., with cultivation for weed control only, by means of hoeing, small cultivators, etc.

"The yields of the two sets of plots were identical as given below:

	Yield per Acre		
	Cane	Q. R.	Sugar
Regular practice	56.2	7.03	7.99
Cultivation for weed control only	55.6	6.91	8.04" [8]

"*A Cultivation Experiment at Hakalau:* In this experiment a gain of almost a ton of sugar per acre was obtained from the plots receiving no animal cultiva-

tion, weed control being done by hoeing. Mr. Verret also reports that 'plots which were not off-barred produced half a ton of sugar more than those which were.' "[9]

Hamakua Mill Company: "No appreciable differences in yield from the various treatments were found, and Mr. Verret advocates that the cheapest method be followed with special consideration to the saving in man-days in times of labor shortage.[10]

Hakalau experiments turned out likewise.[11]

Hilling Up: This operation, formerly practiced on all plantations, on all crops, is now curtailed. The operation comprises the loosening of the soil in the kuakua with 8″ or disc plows, at the time the cane tops from adjoining rows begin to meet. The loosened earth with any weeds or trash was then thrown on to the stools with celery hillers, wedge-shaped "snow" plows, or by handwork with the hoe.

Claims made for this operation were: loosening of the earth, weed destruction, better drainage (especially for upland fields), better support for cane stalks, and covering fertilizer.

To quote James Webster, manager Pepeekeo Sugar Company, "In hilling up, this root cutting is even more detrimental to the root and plant growth, as by that time the roots are all across the kuakua or space between rows and cutting them is depriving the plant of its feeding organs. Not only that, but the good soil is hilled against the cane, leaving a V-shaped ditch between the rows, the bottom of which is in the subsoil and devoid of anything in the way of plant food. It offers also a splendid start for erosion in heavy rainfall. The area to feed upon is reduced, and, while it may be said that the soil is still there, its value is greatly reduced by the fact that a considerable depth of the hill's surface is rendered inert by the way it is exposed to the elements."[12]

Hilo Sugar Co. Hilling: "In this test half of the plots was hilled, and the other half was not, otherwise all treatments to all plots were the same. The results follow:

		Tons Cane per Acre				
Treatment	No. of Plots	2nd Rat. 1919	3rd Rat. 1921	4th Rat. 1923	Average Q. R.	Average Tons Sugar per Acre
Not hilled	10	60.9	68.4	51.2	7.75	7.77
Hilled	10	57.0	66.8	51.9	7.88	7.44

"The average of 3 crops, carried to fourth ratoons, is distinctly in favor of not hilling."[13]

Stripping: The operation of ridding the cane of its dead leaves has received much discussion on the part of the Sugar Planters of Hawaii. Experiments have conclusively proven that the operation is an expensive one but well stripped cane is good to look at, and the tendency is to divert gangs to this operation when urgent work is not at hand.

The subject is quite ably handled by Mr. C. F. Eckart at the Planters' meetings of 1911 and 1914, in which tests on an extensive scale were mentioned wherein an actual loss of labor and dollars was brought about.

Weed Control by Paper Mulching: Cultivation on Olaa Sugar Co.'s lands is mostly for weed control. The nature of the soil, in the lower section, quantities of rocks, and in the upper fields, the heavy rainfall and shallow top soil, forbids the use of implements for covering the dense growth of weeds which are stimulated by excessive rainfall.

Because of these conditions adverse to implement work, the practice of mulching the cane rows with a sheet of bagasse paper saturated with asphalt and oil has been adopted. After harvesting the cane, trash and weeds are palipalied into the areas between the cane rows. A strip of paper 30″ to 35″ wide is superimposed directly over the cane row and held down with any available material (cane trash, stones, dead cane stalks, etc.). In a few days the cane shoots begin to pierce the paper and develop normally. Because the cane row is uneven, some of the shoots expand before they touch the paper. They continue to grow in darkness and force the paper to "tent". About three weeks after papering, these "tents" are cut longitudinally along their ridges, thus allowing these etiolated shoots to mature.

The trash which has been hoed into the kuakuas acts as a mulch against upright weeds and grasses, so the principle weed we have to contend with is the honohono which grows quite luxuriantly, first in the kuakua then, if it is not checked, spreads over the paper.

A modification of the Planet Jr. cultivator, and the hoe is the only means of combating the weeds in the rainy season. The Horner harrow is used but not with the effectiveness obtained on the Hilo Coast plantations.

Weed Control by Spraying: When good weather prevails, spraying with arsenite of soda is an effective means of checking the honohono. A stock solution of arsenite of soda is made by boiling in water 2 lbs. of white arsenic with 0.42 lb. of caustic soda until the solution becomes clear, this is made up to 1 gallon with water. To make a spraying solution for honohono or other succulent growth, dilute this to make 25 gallons. For grasses such as Panicum dilute to 10 gallons. The addition of soap at the rate of 1 lb. (any cheap kind) to 100 gallons of spraying solution increases the effectiveness of this spray by acting as a spreader, causing the solution to stick to the leaf surface rather than form drops and roll off. The solution is effective only on the surface which it touches. Even after thorough saturation the effect of the poison on the soil is only temporary. The spray is applied from knapsack sprayers, the sled sprayer described in the *Planters' Record*, Vol. X, or by a combination of a sled, 50-gallon barrel, and a hand pump equipped with 3-50′ lengths of hose. Meyer's No. 1290 Frembro nozzle is the favorite. Because of the demand for arsenic in fighting the boll weevil in the South, the price is rising to a prohibitive figure.

As the laborer, who sets out to hoe the row himself, misses some weeds, so have I, in writing this article missed some of the operations that might have been incorporated to make it a complete report, so I would be glad of any suggestions or additions. I hope to visit the plantations along the Hilo coast before the meeting in October, and may then have some information and pictures to add.

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[3] August 7, 1919.
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[5] April 6, 1921.
[6] June 6, 1918.
[7] April 9, 1919.
[8] July 12, 1919.
[9] May 10, 1920.
[10] July 10, 1922.
[11] August 9, 1922.
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[12] Proceedings of the Forty-Second Annual Meeting of the Hawaiian Sugar Planters' Association.

A Questionnaire on Seedling Propagation *

By H. F. Hadfield †

The following are replies to a questionnaire on cane varieties and seedlings sent out by the Committee on Hawaiian Cane Varieties and Seedlings of the Hawaiian Sugar Technologists:

In the replies under general remarks:

"*H. P. Agee, Director of the Experiment Station, cautions us as follows:* 'When we select seedlings and find a growing inclination to favor one type over another it is well to carry with us a mental picture of the fact that among the important commercial cane varieties of the world we have such variations in form as occur between Uba, Yellow Caledonia, H 109, Badila, Yellow Tip and D 1135. It will be hard to find in your seedling fields wider variations in type than these six canes present. When all is said there is no criterion to take the place of sugar per acre. For this, we need in Hawaii a cane which will hold over for several months without deteriorating too much, one that will ratoon well, one that will not tassel too freely under average conditions. When it does tassel it must have a capacity to send out lalas from the upper joints to maintain the life of the stalk. Several otherwise promising seedlings have gone into the discard because of the inability to lala and preserve the stalk from rotting back from the top.' "

W. P. Alexander of Ewa, brings out the following points: "In observing seedling growth and in handling the selection of varieties, off and on, for a period of almost eight years, I have found that it is not easy to lay down definite rules for selections because conditions on the Islands vary so much.

"Plant breeding work in other crops is simpler and more rapid than in sugar cane. Sugar cane usually takes 20 months to mature, while most other crops have at least one crop a year. Varietal work in sugar cane requires much patience and results are slow and perhaps at times discouraging.

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* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

† Chairman of the Committee on Hawaiian Cane Varieties and Seedlings.

"To get best results one person must be engaged in the selecting of cane seedlings continuously over a period of many years, not less than six, if possible. He must have a personal contact with the varieties. Weekly inspection of the seedling areas is a great help.

"Observation notes made at least every month are essential if the growth habits of the seedling canes are to be really studied. The finding of a cane to meet particular conditions means that the selectionist must understand what these specific conditions are. It would be a mistake for one to select an H 109 type cane for mauka lands on Hawaii, just as much as it would be to pick a Tip cane for the lowlands of Oahu.

"Progress in selection of varieties depends upon constant observation of the canes by an agriculturist who has an intense interest in his project. In India, where great strides have been made in cane breeding, one man handles only 300 varieties, and devotes his entire time to these alone."

H. E. Starratt of Olaa says: "You have a very interesting topic to handle, and to my mind the subject of varieties and seedlings is the most important in the whole sugar industry of these Islands.

"As no one question asks us point blank how we consider this subject in relation to other problems of plantation and mill, before answering, I should like to bring out a few points on this matter.

"Foremost of all problems is that of procuring the right variety and seedling for the climate or conditions under which you must grow cane. Before a cane is introduced to a locality on a commercial scale, extensive tests should be carried on with it to determine its yielding and ratooning qualities, the sucrose content, susceptibility to disease and insect pests. It must also have good milling qualities, so that the sugar may be extracted, and a sufficient amount of bagasse formed to help keep the fires burning. What plantation has had a sadder experience with varieties than Olaa Sugar Company? Referring to the managers' reports such statements as these are found:

Crop 1906. We are having the same experience with the Lahaina cane which all the other plantations on this Island have had, but we are working out this variety as fast as possible.

We have 3,000 acres available to plant for this crop. This is a large acreage to plant in one season, but we have to use every effort to get as much Yellow Caledonia in as possible.

Crop 1907. Over 1,000 acres of wretchedly poor Lahaina ratoons were harvested which yielded about three-fourths of a ton of sugar per acre.

Crop 1909. There were also included in this crop 500 acres of Rose Bamboo, the last of this variety, which has proved unsuitable for conditions at Olaa and which no longer will be planted.

We planted (1911) 170 acres of D 1135 at Mountain View and 165 acres at Nine Miles.

Crop 1921. Of the plant area 122 acres is H 227.

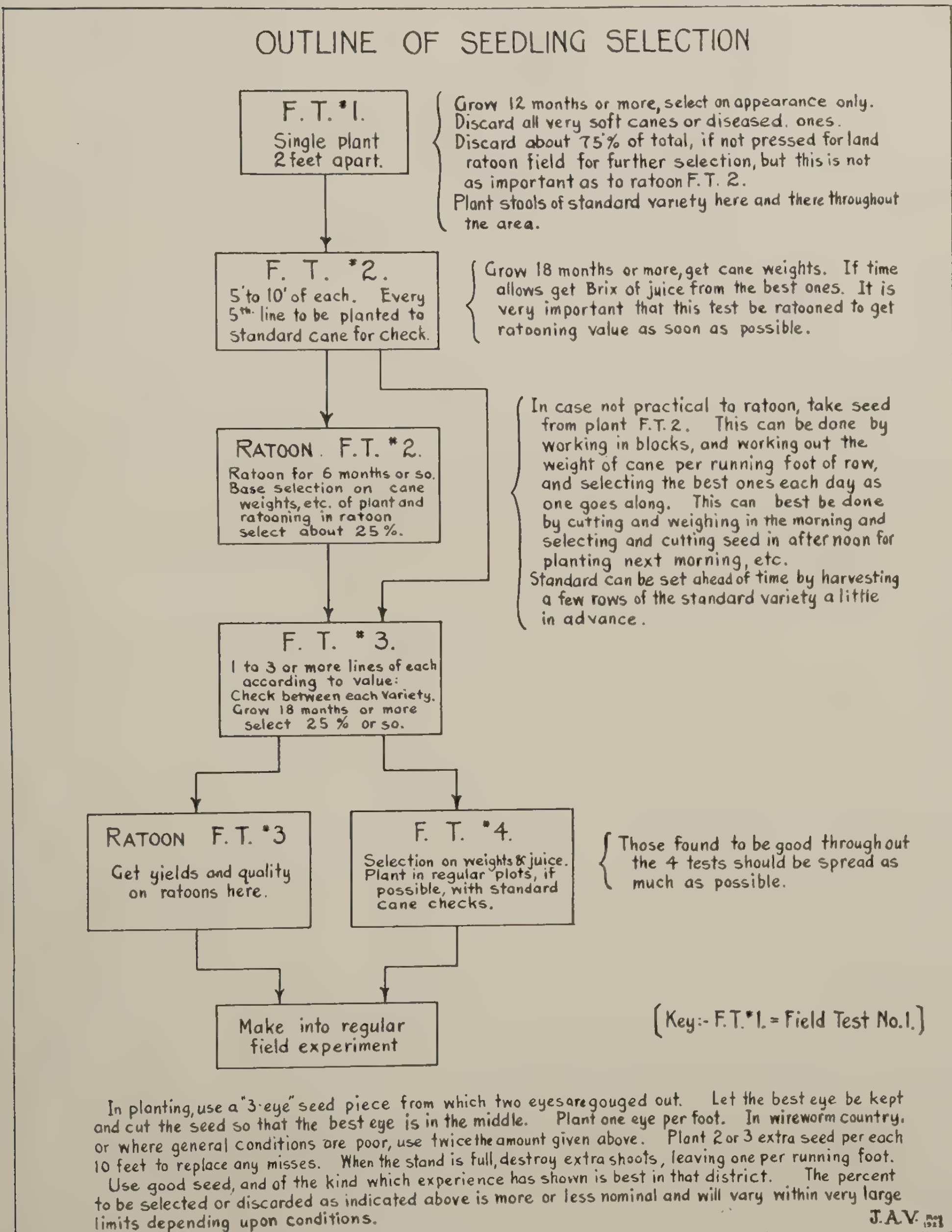
This variety has shown up very well on our Mountain View section, and we intend spreading it as fast as we can.

It seems to be adapted to the climatic conditions up there, and is also much more resistant to leafhopper attacks, than either D 1135 or Yellow Caledonia.

Crop 1923. This year we will have abandoned 157 acres of H 227, as it does not ratoon.

J. A. Verret, Agriculturist, H. S. P. A. Experiment Station, offers for discussion the following, "Outline of Seedling Selection" (see page 55), and remarks:

"The outline as given is not intended to be final but as a matter for discussion. There is some difference of opinion among cane breeders as to the best methods of procedure and it is very desirable to have a full discussion on this.



"A very important point in seedling work, which, in the earlier stages of the work, through lack of sufficient experience, was, perhaps, not stressed enough, is the importance of a careful selection of the parents, bearing in mind the localities in which the seedlings are to grow. For instance, it is obvious that when trying to get a cane adapted to mauka sections, in soils where root-rot is prevalent, the

best parents would not be Lahaina and H 109, but rather the Tips, D 1135, Uba and when available, the recently introduced Java seedlings. In using the Tips as our parent one should bear in mind that these canes are very susceptible to mosaic so the other parent should be from the more mosaic-resistant canes such as Uba, Badila or D 1135.

"In getting crosses for general field work we do not believe it is necessary to go to the trouble of using the cage methods. Our data, based on the handling of many thousand tassels, go to show that most seedlings are the results of crosses in the field. This is shown by the fact that tassels taken from the center of large fields where only one variety is growing, always give very poor germinations as compared to tassels from the edges of these same fields with other varieties adjoining.

"When trying for Yellow Tip and D 1135 crosses, take D 1135 tassels where Yellow Tip adjoins the area to windward, and Yellow Tip tassels with D 1135 to windward. A method used by the Station is to plant the two parent canes mixed in the line, or to plant a line of each, and then to collect all tassels."

Question 1. What cane varieties do you grow on your plantation?

W. P. Alexander, Ewa Plantation: H 109 is the standard variety. Areas are planted to Badila, Yellow Caledonia, H 456, H 468, H 471, H 472, H 5919, H 5946, H 5953, H 5986, Ewa Varieties Nos. 177, 383, 386, 388, 509, 519, 720 and 722. Plot tests of many other varieties including Ewa seedlings Nos. 700, 362, 225, 712, 371, 731, 405, 378, 740, 380 and H. S. P. A. seedlings of 1917 and 1918 propagation.

C. F. Poole, Hawaiian Sugar and McBryde: (a) Makaweli. H 109, D 1135, Y. C., H 146 and Kauai seedlings from 1918 to 1922.

(b) McBryde. H 109, D 1135, Y. C., H 456, H 468, H 471, H 472, a small amount of Yellow Tip, and Kauai seedlings from 1918 to 1920.

A. T. Spalding, Honomu: We grow Yellow Caledonia extensively, also D 1135, D 117, H 456, H 109, H 227, H 72, Badila, Striped Mexican, Yellow Tip, Rose Bamboo, and a few others to a small extent. We are bringing along about a hundred unnamed Honomu seedlings with good success. Sufficient time has not yet elapsed to segregate the very best.

H. E. Starratt, Olaa: 1. Varieties grown here are Yellow Caledonia, on lower lands at Olaa, Kapoho and Pahoa. D 1135 above elevations of 1,000 feet, some on lower lands which is usually short ratooned.

We are investigating H 400 seedlings, especially H 456 for elevation of 1,500 to 1,700 feet, also 1917 Oahu propagations by the H. S. P. A.

Same seedlings for mill region with Badila and Badila seedlings (the last named just planted).

Three seedlings started in 1917.

The "Lyman" seedling started from H 109, is doing well in the hot dry district of Kapoho, and the other two, Olaa 1 and 2, from H 146, are promising for the Olaa district.

John C. Thompson, Hawaiian Agricultural Company: The following varieties are grown on this plantation and in the order of their importance:

Yellow Caledonia,
D 1135,
Yellow Bamboo,
Striped Mexican,
White Bamboo,
Rose Bamboo,
H 72,
D 117.

The following varieties and seedlings are found, having been grown in varietal plots for a number of crops:

Yellow Tip,
Badila,
Black Tanna,
Caledonia Ribbon,
B 306,
D 116.

H 25	H 240	H 5902	H 5953
H 27	289	5904	5955
33	291	5908	5962
45	304	5909	5964
51	311	5912	5965
65	333	5917	5971
68	409	5919	5972
69	411	5922	5973
87	416	5923	5974
109	425	5926	5978
118	427	5927	5986
122	431	5929	5987
126	456	5930	5988
130	458	5935	5994
135	457	5946	5995
145	460	5949	
151	462		
197	463		
202	464		
227	465		
	466		

Stafford Austin, Hilo Sugar Company: We have an assorted number of cane varieties on this plantation, among them are: Caledonia, D 1135, Striped Tip, Yellow Tip, Badila, H 227, 309, 109, and a good many H 109 and Lahaina seedlings that are under observation.

Question 2. What cane varieties or seedlings do you consider best for mauka and makai lands in your district?. Please state your reasons. Replies were received and are given below:

W. P. Alexander: H 109 grows well from 0 to 200 feet, our highest elevation.

Charles F. Poole: (a) Makaweli, makai, H 109; mauka, D 1135.

(b) McBryde, makai, H 109 and Caledonia; mauka, Caledonia and D 1135. However, on either plantation we have not real mauka lands, and H 109 seems to do well anywhere if we can get a dependable water supply.

J. S. B. Pratt, Jr., Associate Agriculturist, H. S. P. A. Experiment Station: For varieties for mauka lands, I would work with Tip and D 1135 crosses, for those seedlings we have already tried show the Tip character of being a cane to close-in quickly. Uba and Badila canes may be good canes for mauka land seedlings. Instead of working with untried seedlings as parents, I figure that our best chances for makai land canes are with seedlings of H 109 and Lahaina parentage. The most promising seedlings to date have come from these varieties.

A. T. Spalding: On the mauka lands of Honomu we have not had much success with any variety. D 1135 is certainly the most promising. We have had several good crops of D 117 off certain areas, but this cane does not ratoon well. Yellow Caledonia is fair. Yellow Tip shows up better a little further mauka on drier lands. Yellow Tip is my idea of a cane between 800 and 1,000 feet elevation. On the makai lands we have tried several varieties including H 109. This cane gives good tonnage per acre, but being a recumbent cane the grass is hard to control. Y. C. is our mainstay yet, although I am sure it is losing its ratooning qualities and in time will "peter out" like Lahaina.

H. E. Starratt: Above elevation of 1,000 feet the D 1135 has given very satisfactory crops, and ratoons very well.

Yellow Caledonia is used on the lower lands for the same reason.

J. C. Thompson: Mauka and Makai Land Canes. Before discussing the merits and demerits of our best varieties and seedlings, it would be best if our conditions here were described. In the first place, the lack of water on this plantation makes it impossible to take the crops off at the right time, causing a loss of sugar, more so if the variety in question cannot stand over. The cold mauka conditions are such that it takes fully two and one-half years to harvest a crop on those lands, for during the four months from December to April little or no growth takes place. The lack of rainfall on the makai lands together with the shallowness of the soils of certain fields is another aspect to be considered in selecting our varieties.

D 1135 has proven the best variety for our mauka lands. It germinates well if good seed is used, grows fast and tillers out better than most varieties. Its ratooning ability is superior to that of most varieties. It is very resistant to most diseases, being more resistant to Yellow Stripe and Pahala Blight than our other varieties. Its upright growth and its ability to shade in well are important factors in the control of weeds in our mauka fields. The yields of this variety are excellent, 550 acres at an elevation between 2,200 and 2,800 feet yielding 68 tons cane to an acre last year.

Yellow Bamboo, our second best mauka cane, is being replaced due to its susceptibility to diseases and leafhopper. It is severely attacked by a fungus disease which breaks down the leaf tissues in spots. Resistant strains of this variety would make an ideal cane for the mauka lands, on account of its ability to stand over better than other varieties.

Rose Bamboo, White Bamboo and Striped Mexican although found growing on large areas in our mauka fields are not what one may call good mauka canes.

H 72 would be an ideal seedling to propagate on larger areas, if it were not for its inability to stand over. It grows well, matures quickly, but goes back if allowed to stand over two years. Its ratooning ability is superior to that of D 1135. If it were possible to harvest our fields on time, H 72 would be an ideal cane.

For the makai lands, Yellow Caledonia has proven the old reliable. It survives the severe drought more easily than any other variety. The shallow soil in certain fields together with the prevailing Pahala blight makes it impossible to replace the hardy Yellow Caledonia with less hardy varieties. Seedlings such as H 227, H 291, H 416, H 451, H 466 and H 416, which have done well in some fields, are not as good as Yellow Caledonia.

The H 400 seedlings are, on the whole, undesirable on account of their inability to shade in and suppress weeds. In fact quite a few of the other seedlings have been discarded for this reason. In a varietal test recently harvested H 416 and H 466 showed up best, the former yielding at the rate of 75.90 tons of cane to an acre and the latter 79.22 tons.

Of the H 59 seedlings H 5965 has proved the best. H 5965 grows very fast, being about the fastest growing seedling I've noticed. It does well up on the mauka fields and also on the lower or makai irrigated fields. Whether it will do well on the makai unirrigated and dry section remains to be seen. This variety is being spread.

H 5972, H 5971 and H 5949 also look well although not anywhere near as good as H 5965.

J. A. Verret: H 109 is not at its best above about 400 feet. Also, it is very susceptible to eye-spot when planted in localities subject to wet winters and no great wind movements. One should therefore be careful in planting H 109 in fields subject to heavy dews and protected from wind. Caledonia begins to be high when about 800 to 1,000 feet elevation. Above that up to about 1,400 to 1,500 feet D 1135 does well. Above this the tips are generally more suitable. These figures are general, only, and vary to some extent in different places. In parts of Hamakua, for instance, D 1135 is better than Caledonia at lower elevations than 800 feet. On the other hand, some of the best D 1135 on the islands are in Pahala at 2,000 feet and over.

Mr. Austin: We consider Caledonia the best cane for our makai lands. The reasons are as follows:

1. Sturdy growth, not too fast to mature.
2. Does not tassel very readily, even at low levels.
3 Hard outer shell, preventing it being eaten by rats.
4. Covers in early, decreasing the cost of cultivation.
5. Does not rot out early, even with big rains.
6. Seems to be our easiest to cultivate in this rainy district.
7. Ratoons well.

We consider D 1135 our best mauka cane. The reasons are as follows:

1. Abundant growth.
2. Good juices.
3. Ratoons exceptionally well.
4. Does not tassel early at high elevations.
5. Ratoon crop very cheap to cultivate.
6. Stands the cold and rainy weather very well.

Question 3. Do you believe in every plantation setting aside an experiment plot for the purpose of selecting seedlings and varieties to suit their own conditions?

H. P. Agee: Any plantation would, I think, profit in setting aside a suitable area for testing seedlings and other cane varieties.

W. P. Alexander: Yes.

Charles F. Poole: Yes.

J. S. B. Pratt, Jr.: Every plantation should have areas to try out seedlings. Our best chances come in working with quantities, and being very rigid in our selection. Canes must be tried out under all conditions on a plantation before being thrown out.

A. T. Spalding: An experiment plot on a plantation should not only be set aside at one elevation, but at several, in order to determine the variety suited to the environmental conditions.

H. E. Starratt: Every plantation should set aside a plot for seedling investigation, and the plot should be reserved for the seedlings until they prove themselves a failure or a success.

Plowing up areas planted to seedlings which are still under investigation on other parts of the plantation is throwing away a valuable score of information.

John C. Thompson: I believe that every plantation, large and small, should set aside experiment plots for the purpose of selecting seedlings and varieties to suit their own conditions. The plantation that carries on seedling work on a large scale will no doubt be most successful.

J. A. Verret: Some of the best of the more recent seedlings we have were started on the plantations. The Wailuku, Makaweli, Kohala and Ewa seedlings are instances, also those of Honomu and Hilo Sugar Company.

Mr. Austin: I thoroughly believe in every plantation setting aside an experimental plot, for the purpose of selections and varieties of seedlings suitable for its own purpose.

Question 4. What, in your opinion, constitutes an ideal seedling cane, supposing you were to set out to grow one?

H. P. Agee: The ideal seedling cane is the one that takes the maximum advantage of the production factors of its environment. Under adverse conditions, where weed control is the important consideration, we need hardy canes which can be handled at a low expense per acre and make a sufficient sugar yield to make that culture profitable. Under good conditions, we want canes capable of high sugar productions so that the heavy expenses of fertilization and irrigation will be offset by heavy yields.

W. P. Alexander: A cane that (a) gives tonnage of cane with high sucrose content, (b) will mature early in the season and yet not "go back" before August or September, (c) will be resistant to root-rot, eye-spot disease and other cane diseases.

Charles F. Poole: An ideal seedling cane for a plantation with high temperature and a good water supply is one that ratoons well, has broad leaves, large heavy stalks, with long joints and strong eyes, and a sound fairly tough rind. However, the real test is the weights and quality of the juices, especially in the ratoons. For a plantation like McBryde, where the water supply is not constant, and the temperature varies, my tendency would be to favor a narrower leaf, but I should not allow any preferences to interfere with the weights and general vigor of the ratoons.

J. S. B. Pratt, Jr.: An ideal seedling cane must first have good agricultural characters, depending upon the plantation. It must be a good ratooner, for we raise ratoons in Hawaii and not plant cane. After canes are selected on their agricultural characters, sucrose content can be the basis for selection.

A. T. Spalding: My idea of a seedling cane is one of the Y. C. type, not necessarily the same color, but possessing the inherent qualities.

H. E. Starratt: An ideal cane must be a high yielder, a good ratooner, have high sucrose, good milling qualities, and be able to resist insect pests and diseases.

J. C. Thompson: From the standpoint of a field man, a seedling with the following characteristics is desired:

1. Good crop.
2. Erect growth.
3. High vitality.
4. Non-liability to disease.
5. Good stooling ability.
6. Good shading ability.
7. Early maturity.
8. Ability to stand over.
9. Good ratooning ability.
10. Very resistant to drought.

The sucrose yield, the percent bagasse, and the percent juice are also to be considered in the final selection of the seedling.

J. A. Verret: The highest average producer at the lowest cost. I know of no way to determine this except by trial.

Mr. Austin: If I were setting out to select an ideal seedling, I would look for the following qualities:

1. Juice quality.
2. Sturdy growth.
3. Quality to withstand disease.
4. Plant and ratoon quality.
5. Covering in quality to afford cheap cultivation.
6. Quality to withstand wet weather.
7. Size of stick.
8. Number of sticks.
9. An ideal seedling should be half way between the erect and recumbent.

Question 5. In germinating seed from arrows, do you find that the quick and slow-growing germinations retain these qualities until harvesting time?

H. P. Agee: We have some indications that strong varieties will show their vigor at a very early age, but we do not have sufficient information as yet, to justify a selection or elimination when the plants are in their infancy. The issue is clouded by the fact that young seedlings may be injured in transplanting and thus show to disadvantage.

Charles F. Poole: There would seem to be this tendency, but there are many instances of exceptions.

J. S. B. Pratt, Jr.: Not enough data to decide, but I have always likened seedling work to a horse race; the horse that is ahead at the first lap is not always the one to finish first.

J. A. Verret: There is some evidence that elimination to the extent of perhaps 50% can be made at the age of three months or so, when transplanting from pots to field. In doing this you run some chance of discarding good canes, but you can handle twice the number in pots and this should much more than make up the possible loss.

Mr. Austin: I do not find that all seedlings retain these qualities until harvesting time.

Question 6. How many selections do you think should decide the qualities of a seedling?

H. P. Agee: We cannot specify a definite number of selections. Our so-called selection is in fact a process of eliminating those canes which show little promise. The severity of this elimination depends upon many factors. The number of seedlings you have in proportion to the amount of land available for this work, and the number of seedlings you propose to start the following year, are important considerations.

W. P. Alexander: It is a process of elimination about as follows: First selection by observation can reject at least 60% of the original plant stools as not worth planting out. Ratoons should be grown and another selection made including those first discarded. Second selection of "line tests" by observation or weighing the cane, can throw out about 50% again. Ratoons are carried on, however. This leaves about 20% ot the original canes in the third selection in plots. Yields per acre and juice analysis are needed. Only those that compare favorably with the standard canes should be cut and planted out again. The number may vary but it will be from 5 to 10%.

Charles F. Poole: At least five field tests, with special emphasis on the ratoon plots.

J. S. B. Pratt, Jr.: The best seedlings must be tried out on field scale before all qualities can be determined. Possibly 75% can be thrown out the first selection, though it is argued that a cane does differently when grown from a seed-piece than from a small seed. However, unless a rigid selection is made, one cannot work with quantities with the same time, money and space.

A. T. Spalding: This is rather a big question. From my experience I could not give any definite conclusion. I think they should be given at least three selec-

tions. On the other hand a cane not promising well mauka might do well on makai lands or vice versa. A longer period of selection might be necessary. This is something deserving of careful study on the part of seed selectionists and field men.

H. E. Starratt: If you have room and can handle large numbers of seedlings, be slow to throw one away until it can be tested for yield and sugar content. If you are restricted for area, leave the seedlings in the original box until, by the law of the survival of the fittest, the number is reduced to what can be properly handled.

John C. Thompson: At least three selections, not including the first planting out of the seedling, should be carried out to decide the qualities of the seedling. This will enable us to judge the seedlings according to the following diagram:

1923 seedling	1924 ratoon	1925 ratoon	1926 ratoon
1924 plant	1925 "	1926 "	
1925 "	1926 "		
1926 "			

Of course this could be carried out only with the best and most promising seedlings, for the poorer seedlings would be discarded after the first and second years.

Mr. Austin: A seedling should run until the second ratoon before a decision is made as to whether it should be kept or thrown out.

Question 7. Would you select a seedling by its ratooning qualities, or by planting it every crop?

H. P. Agee: Our commercial varieties must be satisfactory ratooners. It would therefore seem at first thought that we would be justified in letting our seedling plots ratoon several times and selecting those which make a good showing as second, third or fourth ratoons. In practice there is an objection to this in that we would be carrying very small areas of a large number of canes, when by replanting them we could have larger amounts of a fewer number.

W. P. Alexander: Ratooning qualities are usually the best criterion of a cane's vigor. A plant crop of a seedling may be deceiving as to its true value. I would like a test on both plant and ratoon. Not on one crop alone.

Charles F. Poole: By ratoons.

J. S. B. Pratt, Jr.: A cane's merits must be decided by its ratooning abilities, but until enough material is obtained a yearly cutting will enable us to more quickly judge the ratooning abilities.

A. T. Spalding: By its ratooning qualities. We could not afford to plow up and plant cane every crop unless sugar stayed at war time prices.

H. E. Starratt: Under our conditions, the ratooning qualities of a cane are extremely important, but for several years the promising seedlings should be out at least over a year (more if possible) in order to spread them to a larger test area.

John C. Thompson: A seedling should be selected by its ratooning qualities, although its ability to germinate well in plant cane is quite essential.

J. A. Verret: Good ratooning is essential. No cane should be recommended unless it ratoons well. All plantings after the first selection should be ratooned. We do not believe it advisable to ratoon the first planting from pots, however, on account of the large number of inferior plants.

Mr. Austin: I should select a seedling by its ratoon qualities.

Question 8. How old should a seedling be, when final selection is made?

H. P. Agee: The question is not clear. If you mean what should be the age of a seedling in months when the selection work is done I would state that after two years' growth you can tell more about the ability of a cane to hold over without rotting, but we also encounter the difficulty of getting a nice lot of fresh seed, particularly if the canes have tasselled freely. For this reason, work in younger cane is often justified notwithstanding the disadvantage on the other score.

W. P. Alexander: The age at which a seedling should be selected depends ultimately on whether one is looking for a cane maturing in one year or at 20 months. One reason so many mediocre canes have been selected for two-year cropping is that they are chosen on the record of one season's growth. A large majority of seedlings seem to be rapid growers for the first ten months and then during the second season either stand still or actually die out.

There is, however, a practical side to the technique of selecting cane. First, it is necessary to eliminate the worthless canes as soon as possible. Good land, water, and fertilizer, with the necessary labor involved in cultivation of cane cannot be wasted on a lot of scrubs. We know that at least 75% of our original seedling plants must be discarded sooner or later. Second, if the selection is to be based upon observation, a recumbent two-year old cane is so hidden with trash and the stalks of different canes are so mixed up that it is almost impossible to judge its quality. When the cane weights are obtained this difficulty is not so great.

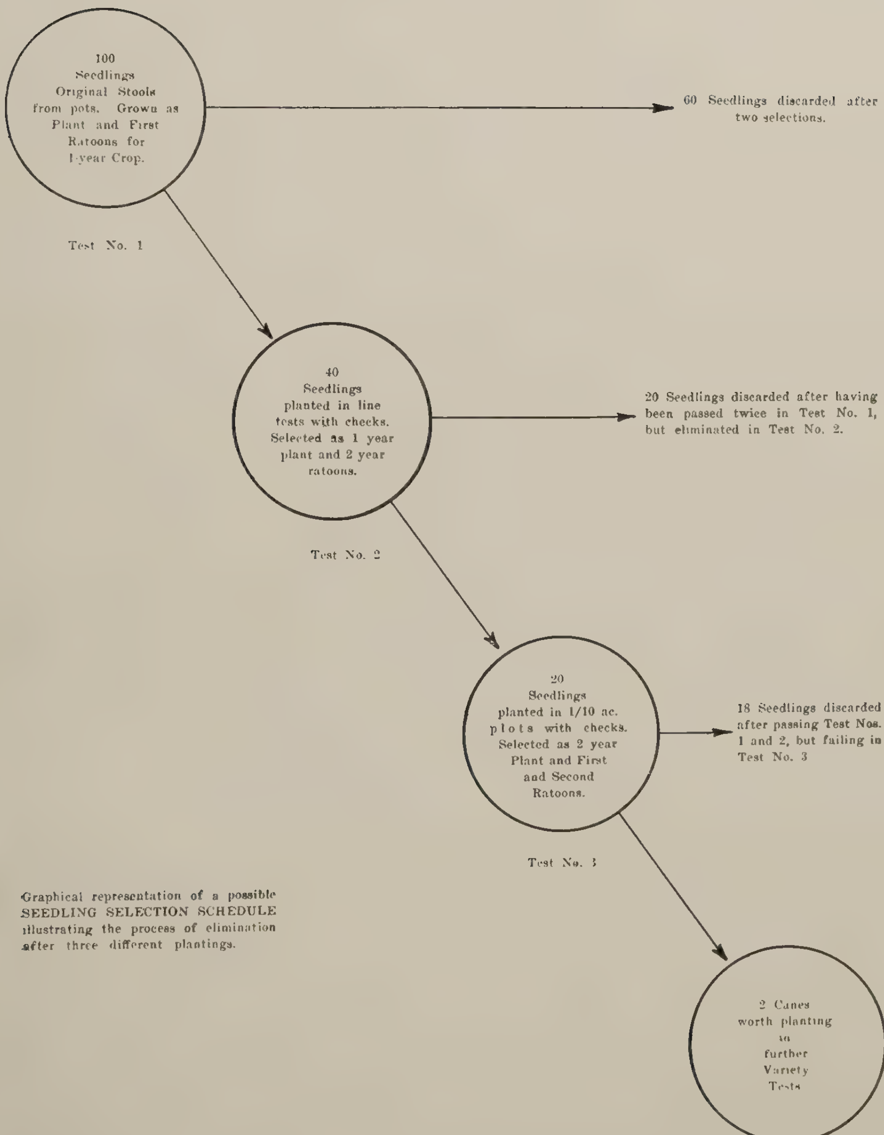
A plan of selection which calls for the first two selections on one-year cane material is a compromise which is O. K., provided eliminations are leniently made. However, by the third year a two-year test should be started, and all the selected ratoons of the first and second plantings should be allowed to ratoon for two years, unless cut for seed on account of the results secured from the third and fourth tests.

Charles F. Poole: The best studies can be made from at ten to fourteen months, while the stalks are still upright, and at this time seed for new field tests is best; but at least one crop, around the second or third field test, should be allowed to run to 20 or 22 months to give weight and juice data, and the following field test could be made from the ratoon.

J. S. B. Pratt, Jr.: I would strive to get seedlings to mature in 18 months.

A. T. Spalding: From eighteen months to two years unless you are an exponent of the two crops in three years theory, then I should say from twelve to sixteen months.

H. E. Starratt: Ten years is a necessary period for a seedling to be observed and tested, before it becomes of commercial importance.



Graphical representation of a possible
SEEDLING SELECTION SCHEDULE
illustrating the process of elimination
after three different plantings.

H 109, started in 1905, began to show up at Ewa in 1913, and only within the last few years, has it jumped into its prominence.

H 227, ten years ago was showing indications of importance, it is now condemned.

John C. Thompson: A seedling should be mature when the final selection is made, even though it may taken only eighteen months for the cane to mature.

J. A. Verrett: The age of a seedling cane when selected (after the first selection) should be as nearly as possible, the age of your cane at harvest. There is some drawback to this in that old tasseled cane will give much less good seed. But one should carefully guard against selecting cane too young. Many canes are splendid at 12 months and mostly dead at 24. That type of cane is not desirable.

Mr. Austin: A seedling should be 18 months on makai lands, and 22 months on mauka lands before final selection.

Question 9. Which do you prefer, a seedling with a large number of thin sticks, or one with a small number of large sticks, supposing their sugar content the same?

H. P. Agee: There is too much prejudice against canes with thin sticks. We are apt to find hardy varieties among such canes and one would do well to bear this in mind in conducting seedling work.

W. P. Alexander: Providing *sugar yield* and also sugar content is the same, I prefer a cane with fewer but larger stalks. The whole process of cultivation, harvesting and milling is more difficult with a small stalk cane. If a better yield of sugar per acre is obtained with a small stalk cane, both in plant and ratoons, we should not be prejudiced against it.

Charles F. Poole: Would fight shy of either extreme, seeking a large number of large stalks, but if compelled to make such a choice would be inclined to favor a large number of spindly stalks as there seems to be a correlation between seed spacing and circumference of stalks, and the spindly nature of the stalks may be due to excellent stooling qualities.

J. S. B. Pratt, Jr.: Naturally, a large type cane is to be desired, but the final answer is tons of sugar in the bag per acre. A large cane is very often a poorer ratooner than the small stick cane.

A. T. Spalding: I prefer a seedling with a medium number of large sticks. Easier and cheaper handling.

H. E. Starratt: Supposing their content to be the same (and also the tonnage) the variety producing the larger sticks is preferable, because of lessened harvesting expense, and because larger sticks strip themselves better.

John C. Thompson: A seedling with a small number of large sticks is to be preferred to a seedling with a large number of thin sticks, provided, however, there is no difference in yield per acre and in sugar content. This would make harvesting easier.

J. A. Verret: For general conditions avoid extremes. But it is a safe bet that as the sticks get smaller, the cane gets hardier and ratoons better, so, arguing from this as the conditions get poorer the most desirable type will have

sticks getting gradually smaller. The idea is to get sticks as big as you can without sacrificing quality.

Mr. Austin: I should prefer a seedling with a few large sticks.

Question 10. Would you plant seedlings in the richest, poorest. or average plantation soil?

H. P. Agee: Average conditions should serve very well. If the canes show promise they can be transferred to poor lands for further trial.

W. P. Alexander: This depends upon the conditions under which you intend to finally grow the cane when it becomes established as a standard variety. There is no doubt that having one test, perhaps the third, under adverse environment, will insure that the cane selected is not a weakling. In any case, check plots, of a known variety must be used for purposes of comparison.

Charles F. Poole: I would prefer average soil, although during the period of five field tests it might be possible to try out all three types.

J. S. B. Pratt, Jr.: There is a big difference of opinion on this question, but I am of the opinion that the seedlings should have the best of care and conditions, *until* enough material is to be had to test them under adverse conditions.

A. T. Spalding: I would try them on every kind of soil. This is another reason why we should not be too hasty in condemning certain canes.

H. E. Starrat: Seedlings should be grown under the conditions approximating those where they will be grown as commercial canes. If a cane is to be developed for Olaa, I would transplant the seedling in an area of uniformly rich soil, for by doing so, the most promising seedlings would rapidly come into prominence, and could be spread to larger areas, because of their rapid growth.

If the seedlings were planted in uniformly poor soil, growth would be stunted and good seed would be slowly formed.

John C. Thompson: Seedlings should be planted in the richest plantation soil only, to get a quicker start and more seed to spread. On a whole it is better to plant seedlings on average plantation soil, since we are looking for seedlings that will satisfy our average conditions and our poorest conditions. What we want now is a seedling which will do better than our standard varieties on our average and poorest soils, for it will no doubt do well on our richest soils.

J. A. Verret: In general I would put the first crop under good conditions. The selected ones should then be tried under all conditions before being finally discarded. On the other hand, if I was attempting to produce a seedling for some specific set of conditions I would start with those conditions at once. In trying for a mauka cane, resistant to root-rot and mosaic, start by getting tassels likely to give crosses of D 1135 and Tip, D 1135 and Uba, Badila and Uba or any other likely canes having some of the characters you desire. Then plant your seedlings mauka and let natural conditions do the selecting for you.

Mr. Austin: I would plant seedlings in the average plantation soils.

Question 11. Do you consider a seedling arrowing at twelve months not worth selecting?

H. P. Agee: If the cane is otherwise good it might have another trial. Since, however, we should work toward eliminating the practice of cut-back, heavy tasselling at an early age is undesirable.

W. P. Alexander: A cane that arrows over 50% at the end of the first season will not serve as a commercial two-year cane. The ability of cane to lala and not die back will be a deciding factor for a cane that tassels less than 50%.

Sugar per acre per month yielded will determine the fitness of a one-year cane, almost regardless of its tasseling character. Under our conditions we would expect .5 ton of sugar per acre per month, in order that a cane be up to standard.

Charles F. Poole: Seed planted in the fall of one year could hardly be prevented from arrowing in the fall of the following year, or 12 months from then, but seedlings arrowing profusely at 7 or 8 months would not make the impression that those requiring longer would make.

J. S. B. Pratt, Jr.: A seedling arrowing at 12 months may be a good cane. H 109 is an example.

A. T. Spalding: Not for our present system of one crop in two years.

John C. Thompson: I do not consider a seedling arrowing at twelve months worth selecting. The new growth of suckers and the going back of an arrowed cane which is very apparent on our unirrigated fields are undesirable qualities. This is clearly demonstrated by Rose Bamboo when planted on our makai lands.

J. A. Verret: Excessive tasseling is not a desirable character, but it may be indicative of an early maturing cane. There is some demand for such a cane.

Mr. Austin: I consider a seedling arrowing at 12 months not suitable for makai lands, but I would give it a chance on mauka lands.

Question 12. Have you any choice in color of cane, with regard to mauka or makai lands?

H. P. Agee: If we begin our work with any preconceived ideas along this line we should be prepared to change them. We should never discard a cane on account of its color, if this is the only fault it has.

W. P. Alexander: No.

Charles F. Poole: No.

J. S. B. Pratt, Jr.: One may have a preference in color, but one cannot correlate color with a good sucrose cane.

A. T. Spalding: No.

H. E. Starratt: D 1135, a red cane, persists at Mountain View, whereas yellow canes have died.

There may be something in the saying that a red cane or dark colored cane is good for upper elevations.

In 1922 I planted all of the red rind seedlings at Mountain View. No results as yet.

John C. Thompson: I believe the dark colored canes are best suited to mauka lands on account of their ability to absorb heat, and the light colored varieties to makai lands.

J. A. Verret: Very dark canes may produce darker sugar and in that way not be so desirable. This is a very minor defect, as rind color is easily removed in refining.

Mr. Austin: No.

Question 13. In judging a seedling, would you favor an erect or recumbent cane?

H. P. Agee: A choice between erect or recumbent canes should not be made in the early work. It is sugar per acre we are after. If the stalks can lie on the ground without too much rotting they should have every consideration. Erect canes are preferred in Java and other warm humid countries because they say that canes cannot lodge without the stalks dying. This is not the case in Hawaii with many varieties.

W. P. Alexander: Recumbent cane for dry lowland, as a cane which lies down gives greater tonnage. An erect cane for wet mauka lands where a recumbent cane will rot or be rat-eaten.

Charles F. Poole: That depends on the age of becoming recumbent; if it remained erect too long that would indicate lack of weight, and falling all over the ground too soon would indicate lack of vigor and might affect the quality of the juice. I should prefer an erect or semi-erect cane till 10 or 12 months.

J. S. B. Pratt, Jr.: The type of cane depends on the locality in which the selection is to be made. A recumbent cane would be more apt to rot in a wet locality.

A. T. Spalding: Erect or semi-erect to my choice. Recumbent, never for our grassy fields.

H. E. Starratt: Given an equal tonnage, I would prefer an upright to a recumbent cane, for the former is easier to hoe and cultivate, and shades the weeds out. Honohono climbs over a recumbent cane, keeping it wet and covered with trash, causing it to rot and root.

John C. Thompson: An erect cane is to be favored in judging a seedling, since cultivation and harvesting are facilitated and there is less chance for deterioration. An erect cane shades in well and suppresses the growth of weeds.

J. A. Verret: Avoid extremes. A wet district requires a more erect cane than do the dry districts.

Mr. Austin: I would prefer the recumbent cane, but not too much that way.

Question 14. In judging a seedling, would you favor wide or narrow leaves?

H. P. Agee: There is a certain relation between the width of leaf and the size of the stalk. When we use the terms "wide" and "narrow" leaves we should think of them in proportion to the size of the stalk. Using the terms in this sense I think we will find most of our commercial canes to have a medium sized leaf. If a leaf is too narrow the plant is apt to be weak. If it is very wide it shades the field too much and holds down the number of stalks per acre.

I find it hard to overcome a prejudice against a seedling with the wide, thick, pulpy leaf. This may be due to the fact that canes of this sort attract

attention on account of their leaf vigor and often fail because there is not an even balance between stalk and leaf.

W. P. Alexander: A large feeding surface of the leaves is essential. A very broad leaf is not necessary, but a very narrow leaf produces a cane of no account. Such canes may be eliminated.

Where weed growth is rapid, as in wet mauka lands, a cane with a broad leaf is desirable. Such a cane quickly closes in and shades out the weeds.

Charles F. Poole: Theoretically, narrow leaves offer less surface for water transpiration, and would seem to favor a mauka location, whereas broad leaves present more surface to the sun, and the greater water transpiration would be overcome on a plantation with high temperature and plenty of water. But the general performance of the seedling at selection, whether mauka or makai, would settle the question.

J. S. B. Pratt: I would prefer a wide leaf in the Hilo district, a larger sugar-making machine. A wide leaf would not be desirable in a windy or dry district.

A. T. Spalding: Medium to wide leaf would be my choice.

H. E. Starratt: I have made no observations that would correlate wide and narrow leaves with the quantity of the cane.

John C. Thompson: Wide leaves are to be preferred to narrow leaves, which do not shade in as well and which cannot perform the work of the larger leaves. Many seedlings are to be found with large sticks and narrow leaves, which I believe is an undesirable quality. Narrow leaves with thin sticks are permissible.

Mr. Austin: I would prefer the wide leaf.

Summary

The following is a summary of the answers to the questionnaire:

Questions 1 and 2: The favorite varieties growing on the different plantations are: For low lands, Yellow Caledonia, Lahaina and H 109; for high lands, D 1135, Yellow Tip and Yellow Bamboo.

Question 3: All agree that each plantation should conduct its own seedling propagation experiments. This is of the greatest importance, for the cane plant not only changes in different countries, but also in different localities.

Question 4: Among the qualities of an ideal cane seedling are: High tonnage, high sucrose content, early maturing (not going back, however, before August and September), resistance to root-rot, eye-spot, and other diseases, good agricultural qualities, good ratooning qualities. That cane which takes the maximum advantage of the production factors of its environments, hardiness, inexpensive cultivation, Yellow Caledonia type, good crop, erect growth, high vitality, good stooling, and shading abilities, ability to stand over, resistance to drought, good milling qualities, and resistance to insect pests.

The climatic conditions on these islands vary so much, that it would be almost impossible to grow a seedling containing all the above qualities.

That cane which takes the maximum advantage of the above qualities would be as ideal a cane as we could wish for.

Question 5: No one has found a correlation between quick germinating seedlings and high tonnage.

All plant breeders in search of a certain quality, the knowledge of which is not known until the plant has reached maturity, also try to find some visible characteristic at an early part of the plant's growth, which definitely correlates with this quality. By this method, a great deal of time and labor is saved, for, those not showing this correlation may be at once destroyed. This factor of correlation is of the most importance, and should be studied by those propagating cane seedlings.

At Hilo Sugar Co., we believe there was some correlation between germination and large tonnage.

From 500 quick growing seedlings of Lahaina parentage, 103 plants were selected for further trial.

Eleven of these were among the best 20 out of 2,000 seedlings. Seven of these 500 were among the best 21 on the second selection. Burbank found correlation to be a great time, space and labor saving method, the burning of the discarded plants being generally known as his $10,000 bonfires.

Among some 15,000 Amaryllis crosses I found that those germinations showing vigor from the beginning, grew to be the largest plants. On the other hand, those which grew slowly, and seemed weak, gave usually a mutant flower, while the vigorous plants gave a flower either like the pollen or ovule parent.

This also applies to the Petunia, the slowest and weakest plants producing sometimes double flowers.

Question 6: Some favor three selections at least, others six and more. One says, "If you are restricted for area, leave the seedlings in the original box, until, by the law of the survival of the fittest, the number is reduced to what can be profitably handled."

It would seem that there should be over three selections.

Question 7: All agree that the ratooning qualities of a seedling cane are more important than its plant qualities, in selection. The seedling plot should be ratooned, and not plowed up after the first selection.

Question 8: As to how old a cane seedling should be when selected, those favoring an early maturing cane favor 12 months, while those favoring a late maturing cane favor 24 months.

Another says that a two-year-old cane will show its susceptibility to rotting, whilst selection proper should be done with young seedlings.

In order to save time, it would seem the proper thing to select seedlings about 12 months to 18 months old.

Question 9: Large and medium sticks seem to be more favorable than a large number of thin sticks.

One member thinks that there seems to be too much prejudice against thin sticks, and that these are generally the hardiest.

There seems to be a correlation between thin sticks and the prolific stooling properties of a cane plant. Under adverse conditions, there is a better chance of getting a good tonnage from a quick shooting cane with thin sticks, than with one with large sticks.

There is a better chance of one shoot surviving out of two or three than out of one.

Question 10: All differ on the kind of soil in which seedlings should be grown. One thinks that it depends where you want to plant them finally. Others, either on the best soil, or under adverse conditions, or on all kinds of soil, or on average soils, and on unfavorable soil.

At the Hilo Sugar Co. we propagated some 2,000 seedlings under somewhat less favorable conditions than plantation cane.

Question 11: The majority think that early tasseling is an undesirable characteristic.

Where it is customary to harvest cane at 18 to 24 months old, the tasseling of a 12-month seedling seems to be undesirable.

Question 12: There seems to be no choice as to color, excepting in one case. It used to be the contention that a dark cane attracts the sun's rays, thus increasing the temperature.

Question 13: Recumbent canes are preferred for dry lands, otherwise erect canes are more favored.

Question 14: Nearly all prefer medium and large leaves, and contend that a narrow leaf is conducive to weakness.

A narrow leaf usually indicates a narrow stick, a large leaf, a thick stick.

A narrow leaf would be somewhat able to withstand drought better than large succulent ones.

Report of the Committee on Boiling*

By Newton Crites

The report of this committee is to deal with the manufacturing of sugar from the syrup stage to the time the sugar is shipped.

Thirty-six letters were sent out to the men in charge of this work, asking for new ideas and methods tried out during the year. No specific questions were asked, but topics were suggested for discussion. From the fifteen replies received few new ideas were found, and in order to make any report at all it was necessary to draw upon the writer's limited experience at Pepeekeo. As a result the following topics, enlarged upon, are submitted:

Commercial Sugar

Clarification of Syrup or Remelt: There seems to be no attempt at clarification of syrup or remelt.

Mr. N. King, of Koloa Sugar Co., allows the syrup to settle as long as possible, while Mr. G. F. Murray, of Hamakua Mill Co., screens his syrup.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Here, at Pepeekeo, we screen all syrup and remelt. The remelt is pumped to a tall cylindrical tank where it settles for seveal hours. It is then decanted through pipes set in at regular intervals down this tank. A great deal of sediment is settled, and all tanks are washed out into the mixed juice once a day.

Use of Chemicals Such as Sal Soda: Only two places report the use of soda ash.

Mr. J. H. Pratt, of Pioneer Mill Co., uses a small amount of soda ash in the remelt, while Mr. W. K. Orth and Thomas J. Nolan, of Ewa Plantation Co., use soda ash to correct acidity in the remelt and low grade pan.

At Pepeekeo, the first part of this year, we did not use sodium carbonate but later, upon the addition of it to the remelt and the low grade pan a noticeable reduction in our waste molasses and ease of handling the low grade was observed. We tried adding sodium carbonate solution to our low grade massecuites after four days in the crystallizers, but with no better results.

Methods of Forming Grain: All replies indicated the use of low grade sugar for seed, with two exceptions.

Mr. Raymond Elliott, of Paauhau Sugar Co., and Mr. F. D. Bolte, of Hutchinson Sugar Co., formed the grain in the pan from syrup to avoid dark centered sugar.

Mr. G. F. Murray installed a new seed mingler of which he says, "The advantages derived from this installation are, increased pan capacity, and from this, a larger grained commercial sugar. The disadvantage is the dark seed grain, which has persisted throughout the crop."

System of Boiling to Produce 97 Degree Sugar: What advantage or disadvantage do you find in making an all syrup and remelt strike, returning all molasses until it is the proper purity for low grade, over repeated back boiling of molasses? How do you make a 97 degree sugar and a 50-52 molasses?

The method of frequently making all syrup strikes, seems to be the general operation since the refinery requested 97 degree sugar.

Mr. J. H. Pratt writes:

> We make three grades of first sugar. A straight strike or "A"; all the molasses from the "A" strike is taken back in the "B" strike; all the molasses from the "B" strike is taken back in the "C" strike. The "C" molasses is boiled for low grade. This system is very flexible; if the initial purity is high an extra or "D" strike may be boiled; when the juice is low, the "C" strike may be omitted. It has the advantage of clearing the house frequently, there is no closed circuit for the molasses. Remelt is taken into all three classes of strikes.

Mr. V. Marcallino of Waiakea Mill Co. reports:

> Since 1921 we have been boiling all syrup strikes and returning all molasses until the proper purity for low grade is reached. The results have been gratifying, in that the sugar has been of satisfactory polarization and grain size. This year, the purity of molasses boiled for our first low grade has averaged between 51 and 52 and the sugar which has reached the refinery averages about 97.25 polarization.

Mr. W. K. Orth and Mr. Thomas J. Nolan:

> We prefer the method in which the molasses is returned to obtain a set purity of massecuite, an "A" massecuite of 80 and a "B" massecuite of 76 purity. This latter

furnishes molasses for the low grade strikes. This molasses we aim to keep at 56-58 purity. With the initial purities of our juices, this is often accomplished with one boiling. But even recognizing the dangers of reboiling, we prefer this system on account of the resulting, even quality of sugar. Twice a week we boil off all the molasses, thus avoiding excessive reboiling. The purity of molasses allows of direct graining without the aid of higher purity material for a footing and gives, under our condition, a good working low grade and final molasses of satisfactory purity.

Mr. F. D. Bolte boils off all molasses once a week, while Mr. G. F. Murray makes a new strike to six mixed strikes.

The first part of the season, at Pepeekeo, we boiled off all molasses once a week and then changed to making one new strike to three mixed strikes, which resulted in our low grade drying much better. This may have been due to the change or it may have been due to the character of the incoming juices. The first part of the year our mixed strikes produced a 97.2 sugar and a 50 purity molasses, but as the season advanced the polarization of the sugar dropped and the purity of the molasses increased. This necessitated a change in boiling, to keep the sugar at the proper polarization with a corresponding low first molasses.

Introduction of Remelt; Where and Why? With one exception, all replies indicated the introduction of the remelt into the pans.

Mr. William Ebeling, of the Hawaiian Sugar Co., does not have any remelt as he uses all low grade for seed.

Mr. Raymond Elliott reports:

The remelt, i. e. our No. 2 and 3 sugars dissolved in clarified juice to about 70 Brix, is then pumped to a receiving tank where it runs into the mixed juice. In this way the remelt is limed, heated and clarified again. The reason why we add the remelt to the mixed juice instead of sending it to the pans is: All of our cars and tanks are of the open type. The No. 2 and 3 sugars from open cars and tanks are far from being clean, and by returning them to the mixed juice most of the impurities are eliminated. Then the question of acidity and alkalinity arises. The house is run alkaline so as to give an alkaline first sugar. The resulting molasses from that is always acid when boiled to blank. Naturally the No. 2 and 3 sugars are acid and that again, is corrected when the remelt is returned to the mixed juice. If we were to take the remelt into the pans, NaOH, or some such chemical that is highly basic, would have to be used in order to bring the No. 1 sugar to an alkaline point.

Mr. W. K. Orth and Mr. T. J. Nolan:

We treat remelt as syrup and work it as such. No benefit is derived from reprocessing remelt by sending it again through the ordinary clarification process. There are no advantages to offset the disadvantages, such as higher sugar in mud, the usual deleterious effect on the clarification of the juice, and the dangers incident to unnecessary heating of sugar solutions. Only special processes, as perhaps double purging of low grades, might improve remelt without prohibitive cost.

At Pepeekeo, we tried introducing the remelt to the mixed juice for two weeks but it upset the chemical control of our continuous clarification system, so that it had to be discontinued. The aim was to aid in the purging of the low grade by eliminating the impurities, but the expected results were offset by the poorer quality of juice produced.

Cause and Prevention of Conglomerates: There were but a few replies to this topic, but the general belief is that conglomerates are caused by poor circulation in the pans, and sticky condition of syrup or molasses.

Mr. W. K. Orth and Mr. T. J. Nolan:

Conglomerates are, in our opinion, mainly due to poor clarification; poor circulation in the pan; lack of skill in boiling; poor quality of seed (uneven); quality of the juice (gums).

Mr. G. F. Murray:

Conglomerates show up in my straight strikes the same as the mixed strikes, though not to the same extent. My experience in the beet sugar business leads me to the conclusion that they are due to the gummy, viscous material in solution in our syrup and molasses, and we can look for no improvement until we improve the clarification of these products.

At the Western Sugar refinery, there was a one hundred-ton pan that always caused the grain to roll up. Shortly after the pan was grained the crystals began to stick together and no matter what the operator tried the results were always the same. The writer saw only one pan of lower purity sugar that did not form conglomerates. The reason given there, was poor circulation in the pan, which the engineers could not remedy.

Washing of Sugar: No new methods or liquids were used in the washing of sugar this year. The amount of water used varies from one pint to four quarts to a forty-inch machine, the quantity depending on the polarization of the sugar needed. Mr. N. King found that adding the water one minute after the machine was started gave the best results.

The use, in Hawaii, of unsanitary tins and buckets in place of a sanitary hose or automatic machine in the washing of sugar is common practice. It seems that when precautions are taken to provide pure water in washing that the benefits derived are offset by the methods of application.

Low Grade

Preparation of the Molasses Used in the Strike Such as Heating, Skimming, and Addition of Water: In nearly all mills the molasses is heated to about 160 degrees F. by steam, and diluted to about 80 degrees Brix.

Mr. W. K. Orth and Mr. T. J. Nolan reply:

We heat molasses to about 170 degrees F. by blowing steam into it, we further dilute to 75-80 Brix and agitate during this time by means of a propeller.

At Pepeekeo, all molasses is heated to 160 degrees F. and skimmed to remove impurities that rise with the froth. Molasses, used for low grade work, is diluted to 50 degrees Brix and taken into the pan that way, no extra water being used. In this way the quantity of water can be regulated more closely than by merely opening the water valve at the same time molasses is added to the pan.

Methods of Forming Grain: The general method seems to be to either shock seed or concentrate in the pan until enough grain appears.

Mr. W. K. Orth uses a molasses of 58 purity while Mr. A. L. Grandhomme of Lihue Plantation Co. uses one of 52 purity in graining.

Mr. J. H. Pratt reports:

About 8 or 10 tons of molasses from the "B" strikes is blown up as little as possible, so as not to dissolve the small grain formed when the molasses strikes the centrifugal casing. This is pumped to a separate tank and is used for seed. It has the advantage of saving time, and the evaporation of a small amount of water, and of not having a "dark seed" for the nucleus.

At Pepeekeo, the method used has been to boil about 300 cu. ft. of 52 purity molasses to about 94.5 Brix and drop it blank to a graining tank below where grain gradually forms. There are two tanks, one tank is graining while the contents of the other is taken up and the grain built up with molasses. The main objection was that even though the purity and Brix of the molasses were correct, the grain might or might not be the proper size. Often, under the same conditions, false grain as well as uneven grain appeared. The grain usually had a dark center due to insoluble impurities in the molasses. During the middle of the crop we started to add about one pound of white "Dessert Sugar" five minutes before dropping the blank and boiling to only 92.5 Brix. We got an absolutely uniform clear grain, the size depending on the Brix of the blank. The purity of the waste molasses immediately dropped over one point and the low grade dried much better, giving a uniform seed for our No. 1 sugar.

The use of powdered sugar in boiling blank low grade should certainly improve the formation of the grain, and all operations effected by the condition of the low grade sugar.

Cause of False Grain: False grain in low grade seems the most important factor that prevents the molasses from being properly exhausted.

Mr. W. K. Orth's reply sums up the main reasons for false grain. He says:

Some reasons for false grain are, having the molasses entering the massecuite in the pan at too low a temperature or too heavy; too fast boiling; keeping the massecuite too thin, especially after the pan is half full; foreign grain entering with the molasses charges; too small a quantity of grain to start with; poor circulation in the pan; irregular feeding; great variation in the purity of the molasses for the same strike, if unknown to the pan man.

Mr. G. Giacometti has had trouble with false grain forming in the crystallizers. He says:

However, the problem that has interested us most was, and is, how to lower the purity of our final molasses. With the help of a microscope we can follow and control the formation and size of the grain. We are perfectly satisfied that the massecuites are free of false grain when dropped into crystallizers, but after a day or two false grain does appear. We have tried every combination as to purities, densities, and size of grain, but without permanent results. It is evident under these conditions that we can not hope to exhaust our molasses by extra high density, since this will promote an extra large formation of false grain later on. We are still undecided whether the primary cause is in our mechanical arrangement or in our boiling method. We tried to grain our low massecuites directly from molasses, and from molasses and syrup but with no apparent different results.

At Pepeekeo, I have never seen false grain form in the crystallizers, but when present, it is always found just before the pan is dropped. The reason it does not form in the crystallizers is because the mother liquor surrounding the crystals has been exhausted to a purity of at least 36. The cause of false grain in the pan is that the mother liquor is not sufficiently exhausted before another charge of molasses is taken in, or, in other words, that the massecuite is kept too thin near the finish of the strike. When thick molasses and water are taken in the pan at the same time, the water has a tendency to rise to the top, leaving the molasses below, and as this is concentrated, false grain will appear. This trouble can be avoided by diluting the molasses before taking it in the pan.

Brix and Purity of Massecuite and Purity of Hot Molasses. Can You Make as Low a Waste Molasses from a 55-60 Massecuite as from a 50-52 Massecuite? This topic was not discussed at any length in any of the replies. Merely the Brix and purity of the low grade was given. The question as to the proper purity of low grade for the best exhaustion of the molasses has been brought to my attention several times. From the reports sent in it seems that those mills with the lowest purity massecuite exhaust their molasses more thoroughly. The equipment of the mill has much to do with it, as a lack of machines will necessitate a higher purity and a quicker drying massecuite.

Our average at Pepeekeo this year was, massecuite Brix 98.1, purity 50.5, hot molasses purity 33.3 and gravity purity of final molasses 34.8, while at Lihue Mr. A. L. Grandhomme reports a massecuite of 97.5 Brix, purity 51.4 and a final molasses gravity purity of 34.9. Mr. W. K. Orth had a higher purity massecuite and a higher purity final molasses. He reports a Brix of 100, purity 57-59, hot molasses purity 40.5, and a gravity purity of final molasses of 35.5.

Advantage or Disadvantage of a Large Grain: Mr. W. K. Orth and T. J. Nolan report:

A reasonably large grain, if it can be produced without false grain, gives the distinct advantage of more rapid and better drying sugar than small grain (of otherwise equal strikes), and consequently brings less low molasses back into process. At first sight it appears more difficult to bring the molasses down to low purity with large grain, but in the long run that may not be so when one considers the detrimental effect of the often very low purities of seed and remelt, due to poorly drying grain. A smaller grain permits of faster boiling, and leaves much less danger for false grain forming. A medium grain of about .3-.4 mm. seems, to our experience, to be the most advantageous.

Mr. Chas. P. Bento, of Wailuku Sugar Co., tries to get a grain .5 mm. in size.

The results at Pepeekeo show that the size of grain has little to do with the exhaustion, but the inability of the pan men to keep false grain out necessitates a fairly small grain.

Effect of Acidity of Clarified Juice on Drying of Low Grade: There was but one reply to this topic.

Mr. J. H. Pratt writes:

During the crop we ran for one week with neutral juice, during the remainder of the crop our juice was alkaline to phenolphthalein. No difference could be noted in the drying of the low grade boiled during this week and the molasses was the same purity.

A few years ago most mills carried their juice neutral, or slightly acid to litmus, because the low grade would dry better. There has been a gradual change towards alkaline juice even going as far as alkaline to phenolphthalein, yet there seems to be no difficulty in the drying of the low grade. Was it a superstition, or does the increase in lime remove more impurities to offset the more alkaline juice?

At Pepeekeo, we ran the house .6 acid to phenolphthalein for two weeks, and found the low grade did not dry as well as at .2 acidity since our juice was not as clear.

Crystallizer Work

Method Used to Get Maximum Drop. Use of Dilutant, Such as Water or Molasses, and When Applied: Mr. W. K. Orth and Mr. T. J. Nolan replied:

We advocate boiling to 100 Brix, dropping at low temperature, adding slowly 17 gallons of water to 7,500 gallons of massecuite, and keeping in motion about eight days in crystallizers. We found by tests that in eight days we can expect most molasses to be practically exhausted, although eleven days or more would be required in some cases.

Mr. Wm. Lougher, of Hawaiian Commercial & Sugar Co., writes:

We have noticed a very decided improvement in the working of all boiling house products since the installation of the Petree process. Low grade massecuite was especially improved, so that we only were using one-half of our low grade centrifugal capacity, in spite of the fact that we were drying without adding water to the crystallizers.

Mr. Wm. Ebeling dilutes massecuite in the crystallizer to about 93 Brix before drying.

Mr. A. L. Grandhomme adds water to the massecuite, it being in a screw conveyor on its way to the mixer.

Mr. N. King does not add water until after the fourth day when it is added in ten-gallon portions to the crystallizers.

A disputed question at Pepeekeo has been the Brix at which the massecuite should be dropped. Will there be a greater drop by boiling to 99 Brix and diluting to 95, or by dropping at 95 with very little dilution? Several factors enter into the solution, but we have found that a 98 Brix is the most convenient one. In finishing a pan it is boiled about three hours with only water added. After each addition of water the contents of the pan is boiled a little thicker so as to thoroughly exhaust the molasses. With such a high Brix in the pan, too much time is required to thin it down to 95 Brix, as the circulation is so poor that the water evaporates before it has mixed with the massecuite. Our crystallizer capacity is such that we can dilute before pumping to the necessary Brix for drying.

The effect of water added to a massecuite after 96 hours in the crystallizer, and the drop in purity of the molasses with the corresponding drop in temperature, is illustrated in six crystallizers examined during the crop:

Brix of strike when dropped	97.6	97.6	98.4	98.7	99.1	99.2
Purity of strike when dropped	50.3	51.3	49.4	48.0	51.8	49.2
Purity of hot molasses from strike	30.8	32.8	28.9	29.9	32.4	29.6
Purity of molasses in 12 hours	29.7	29.9	26.0	28.0	29.7	27.9
Purity of molasses in 36 hours	28.3	27.8	26.2	25.7	28.8	26.4

Purity of molasses in 84 hours	25.7	26.1	22.8	24.1	25.9	25.1
Temperature when dropped	53	56	54	54	54	53
Temperature in 12 hours	52	51	51	53	52	52
Temperature in 36 hours	47	46	50	45	47	47
Temperature in 84 hours	40	35	38	37	37	38
Brix Mass. before drying	97.0	95.7	96.9	95.0	96.2	95.5
Purity molasses before drying	25.8	25.8	23.3	25.1	27.9	25.5
Hours in crystallizer	144	144	144	192	168	192

The results are not very consistent, but show in a general way the effect of dilution of massecuite with water, and the fall in purity of molasses corresponding to the drop in temperature.

Use of Steam or Water in Drying: From the replies received it seems that no water is used in the machines.

Mr. Chas. P. Bento uses steam around the baskets, as does Mr. W. K. Orth, who considers its effect on purity insignificant.

At Pepeekeo, we use from one to two pints of water in the machines and get an increase in purity at machines of 2.3. This is due to the use of water and the fact that sugar sifts through the screens. The latter raises the purity about one point.

Handling of Commercial Sugar

Conveyors. Cause of Breaking of Sugar Crystals: Most of the replies seem to indicate that part of the total small grain is due to conveyors.

Mr. G. F. Murray writes:

Any type of conveyor that drags the sugar along in a trough or flume is bound to break up a considerable amount of grain. Conveyors of the grass-hopper or belt type will obviate this trouble.

Mr. W. K. Orth:

We changed the conveyor from screw to grass-hopper, on account of breaking crystals.

Mr. Wm. Ebeling:

Here, we have iron scraper conveyors and I find them breaking and grinding the crystals.

Mr. N. King:

Our scroll sugar conveyor is perhaps not the best, as far as the prevention of crystal breakage is concerned, but we have no trouble to speak of with it.

Mr. J. H. Pratt:

We use both scroll and bucket conveyors and they are both very long. As our average "total small" was less than 19 for the crop, any breaking up of the sugar can not be very serious.

The writer is inclined to agree with Mr. Pratt as the percentage of crystals that come in close contact with the conveyor is small compared with the total number of grains conveyed.

Cooling of Sugar: Mr. J. H. Pratt writes:

Our sugar is cooled by dropping on a revolving disc. We also blow a small current of air through it as it drops into the bagging bin.

Mr. W. K. Orth and Mr. T. J. Nolan:

We use Hersey driers to cool the sugar and believe them of great advantage. The massecuite may be dried very hot, and still the sugar be cool enough when bagged to allow 130 pounds in the ordinary 125-pound bags.

Mr. Chas. P. Bento:

A large sugar bin with a revolving disc, and a twenty-inch vent pipe to the atmosphere is recommended.

There is a general tendency towards cooling the sugar before bagging, the main reasons being to prevent caking and deterioration.

Cause and Prevention of Caking of Sugar in Bags: During the time the refinery sent in reports this year very little caked sugar was reported.

Several reasons for caking and its prevention were reported.

Mr. Chas. P. Bento:

Caking is prevented by cooling sugar before bagging and applying water at machines.

Mr. A. L. Grandhomme:

Caking results when the sugar is not dried well enough, or taken out too soon from the baskets, and when the molasses is too sticky.

Mr. F. D. Bolte:

Moisture and false grain cause caking.

Mr. G. F. Murray:

My sugar is bagged hot and loaded direct into the cars, or, on occasion, piled on the floor. I have had sugar stored in the sugar room for months at a time, but have never experienced any caking in the bags, so I am unable to venture any means of prevention.

J. P. Frank, of Onomea Sugar Co.:

During the past grinding season, some trouble had been experienced due to a defective seal of the water leg on an individual condenser. The vacuum dropped below normal level, subsequently necessitating boiling under a higher temperature; during which time caked sugar was reported. Since the defect was remedied, and simultaneously with the return of normal boiling conditions, the sugar has not caked.

Mr. H. F. Hadfield, of Hilo Sugar Co.:

A film of hot, highly concentrated sugar solution between two crystals of sugar, upon cooling, will harden and the crystals will stick together. I believe this is the recognized theory of caking of sugar.

A big percentage of caked sugar has come from those mills situated along the wet part of the Hamakua Coast. It seems to the writer that weather conditions have a lot to do with the sugar caking, as mills situated in different parts of the Islands handle the sugar in a similar way and yet are not troubled with

caking. Olaa, where the sugar is passed through a Hersey drier, has less trouble with caked sugar than mills in the vicinity of Pepeekeo, so that its use improves conditions considerably.

An interesting contribution from Mr. Dean G. Conklin, of Kahuku Plantation Co., is here given:

As a contribution to your report on Boiling House Methods, I beg to submit a description of certain operations at the Kahuku factory which may be of interest:

Straining Raw Juice: During this year, a part of the raw juice has been sent through a 100-mesh Peck screen before going to the heaters. It was hoped to be able to send all the juice in this way, but trouble at the filter-press station made it desirable to leave some bagacillo in the juice in order to form a cake. As will be described later, it was found possible to strain all the juice and still get a good cake. The fine bagacillo removed by the strainer was put back on the mill along with the returned third mill juice. For the greater part of the season we have had excellent clarification and a low molasses. How much of this can be ascribed to the screening is uncertain, as the operation of the screen was interrupted several times during the season for alterations. Nevertheless, the results for the year show such a decided improvement over previous years, that at least part of this must be due to the fine screening.

At the first part of the season, we followed the usual practice of clarifying the first and second mill juices separately. The first mill juice was screened. On the second week in July we changed the system, mixing the juices as in usual practice, straining it all, liming after straining, and thence to scales and heaters. In spite of a very poor quality of juices, there was no difficulty in sedimentation. The settlings were heavily limed, brought almost to the boiling point in blow-ups, and sent to the presses under 25 lbs. pressure. Here again there was not trouble, a perfect cake was formed, filling the frames completely, and washing fairly readily. Our washing arrangement is imperfect, otherwise we would have shown a smaller loss in this operation. A cake 1¾ inch thick was obtained, and of remarkably low moisture content, down to 60%. The polarization varied, according to the time of washing, from 1.0 to 5.0%. The runnings from the presses were highly alkaline, and were returned to the raw juice, the lime addition to the juice being reduced proportionately. This made our settling tank station a little crowded, so we resorted to emptying the tanks of the settlings every other fill. We operated under these conditions throughout the balance of the crop, about six weeks in all, with better results, as regards quality and ease of work, than for the rest of the year. It is of interest to note that after the juice was strained, there was no collection of matter on the 100-mesh screen through which the clarified juice ran, showing that the first screening was thoroughly effective. For next season, we are putting in a new battery of cylindrical settling tanks and will have six modern filter-presses at work, therefore we confidently expect still better results at these stations.

Cleaning Evaporators: We have used the method of boiling out the evaporators with strong soda-ash solution followed by weak acid all season, with very good results. Our evaporators have been clean, as shown by the syrup densities for 1922 and 1923 of 56.00 and 64.17 respectively. The work is easy, the men being out of the factory Sunday mornings by 10 o'clock. Our method is as follows: After emptying the evaporators, they are filled to the tube sheet with a 14% solution of soda ash, the manholes of the evaporator are closed, and a manhole on the vapor line is opened. The evaporators are boiled at atmospheric pressure for 12 hours, replacing from time to time the water lost by evaporation. We allow the solution to concentrate the final hour so that when finished it is about one foot below the top of the calandria. The solution is run into a storage tank, and the cell washed, the washings also going to the storage tank until the volume of solution is the same as at starting. Any additional wash water goes to the sewer. The cell is then boiled with a .25% solution of muriatic acid, replacing the acid lost by reaction with the scale, and finally completing by emptying and washing with water. We have found that it is necessary to supplement the soda ash solution with two bags of

soda ash (600 lbs.) each week. There is a saving in both labor and supplies. In 1922 we used soda ash for cleaning, in the usual manner. Possibly, if we were provided with a container, we could have saved considerable expense. As a matter of interest, I give some cost figures:

	1922	1923
Tons Sugar per Day's Labor Cleaning Evaporators	13.04	26.14
Cost per Ton Cane, Labor	.0086	.0052
Cost per Ton Cane, Soda (Caustic and Soda Ash)	.0271	.0181
Total Cost per Ton Cane	.0357	.0233

I have not included the acid expense, as the records are incorrect. To this financial advantage must be added that coming from the possibility of higher concentration in the evaporators and heat conservation.

Low Grade Boiling: Grain is caught in a 285 cu. ft. coil pan on a 70 purity footing, by shock seeding. We use only about 20 grams of powdered sugar for this purpose. The pan is filled with first molasses, taking about 10 hours, and then cut over to a 600 cu. ft. calandria pan, there being just enough to cover the top of the calandria, and the boiling continued with the first molasses. We generally boil at this pan about 20 hours. Only exhaust steam is used, at 2 lbs. pressure at the calandria, the temperature of the pan being 150 degrees during boiling and 130 degrees when dropped. The average brix is 98.7. The second massecuite is held 11 days in crystallizers, and then dried in a battery of twenty 30-inch machines. Usually, before drying, we add 2 to 4 buckets of a 10% soda ash solution. The machines dry in from 30 to 45 minutes, giving a melt of about 80 purity and a molasses of 96 brix, and 30 to 34 gravity purity. Probably, our good molasses results follow from the fact that we have removed so much fine matter from the juices before liming and heating, but we are more inclined to give credit to our ample pan capacity and slow boiling, and skill at the pans. Since starting this system of boiling, the second pans have always had a grain of uniform size, and there is no difficulty in drying when we mix successive crystallizers in the mixers. It has been suggested, also, that our low molasses is because of the high glucose content, which sometimes reaches 25%, and this may be also a contributing cause. We are satisfied that this high content in glucose is not attributable to inversion. During a short period we carried a glucose-ash balance on juices and molasses, and there was no measurable increase in ratio, rather a decided decrease. That there was no inversion is further shown by our balance statement which records an undetermined loss of only .27% of polarization cane, a boiling house recovery .64% over theoretical; and for the first time in this house a figure for tons cane per ton sugar practically the same as the quality ratio, being 9.57 and 9.52 respectively, with an extraction of 96.0. In former years there has been a difference of 0.5 to 1.0, between tons cane per ton of sugar, and the quality ratio.

Boiler Room Equipment*

By Alvah A. Scott

The subject of Boiler Room Equipment and Boiler Operation has been so thoroughly and ably discussed in previous papers presented at previous meetings, that at first thought it would seem almost impossible to find material for a paper which would form the basis of a real live discussion at the coming meeting. It

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

is often the case, however, that in discussing the things that are self-evident and appear big, because they are new, we overlook the smaller, everyday problems which are troublesome and should be discussed.

In the hopes of unearthing some of these problems the writer wrote to all mill engineers in the Territory, as far as he could determine. Sixteen replies were received and in these are points which are well worth mentioning and discussing. Some of these may appear of minor importance, but the writer has found that if the minor things are given proper attention the bigger things take care of themselves.

To give all the replies in full would make too lengthy a report so the various points brought up by each are briefly given.

Mr. Johnson, of Wailuku, writes that a separate Venturi Hot Water Meter installed on the boiling house boilers "has furnished indisputable evidence of the rate and regularity of steam being drawn from these boilers during every hour of the day and night shift, and furnishes the engineer a check on the operating efficiency of the plant." The separate determination of the steam consumed by the boiling house may be a more or less common practice but, if not, it would probably aid in economizing on steam, when this is an important factor, by localizing the points of maximum steam consumption and thus indicate where a change in method of operation might result in a saving of steam. There is no doubt, also, that definite information as to the steam consumed by the crushing plant and the boiling house separately removes a possible cause of friction, between the engineer and boiling house staff, which is liable to occur when fuel economy is the watchword. It is human nature to blame the other fellow unless we have definite information to the contrary.

Mr. Akana, Acting Engineer at Kilauea, writes as follows:

One very minor point that is new to us, but which is undoubtedly used elsewhere, consisted in putting a sliding gate in the bottom of our smokestack flue outside the boiler. At night when the mill is shut down this gate is opened so that the smokestack draws the air through here during the night instead of through the boilers. We find by utilizing this gate that our boiler temperature in the morning is 40 degrees higher than is the case when this gate is not used.

To factories operating on single shift and who do not already have an arrangement as above this may offer a worthwhile suggestion.

Mr. Chalmers, of Waiakea Mill Company, points out in his letter that they intend to overcome, if possible, a shortage of fuel by increasing the heating surface of two of their 7x20 return tubular boilers without any change in boiler size. This will be done by using 3″ tubes in place of 4″ which will increase the number of tubes from 118 to 186 and the heating surface by 900 square feet or 450 square feet per boiler.

Mr. Chalmers feels confident that the change will work out, as he states it has done so on plantations where it has been tried.

Mr. Purcell, of Ewa, reports a marked improvement in conditions in the power house, where the steam is mostly used from two Stirling boilers equipped in 1921 with superheaters. No definite da*a is available, however, as performance records were not kept. Superheating of steam is practiced very little in the

island factories, and it is doubtful in most cases whether there would be any economic benefit. But, it is possible that under certain conditions and steam requirements they would effect a saving. It would seem to the writer that definite data would be well worth obtaining.

Mr. Purcell also reports that a compound, duplex pump of the outside packed plunger type, installed to replace two worn out feed pumps, has given splendid service. It is equipped with automatic regulator, is fitted with metallic packing and, with the exception of a turn of packing added all around a few weeks after it had been put in use, has required no adjustments or repairs. He further adds that home-made tube blowers installed on their four tandem boilers have proven very satisfactory.

The old small boiler feed pumps with hand regulation are rapidly giving way to automatically regulated pumps of the general type mentioned by Mr. Purcell, and are of ample capacity to handle, in most cases, all of the work. These new installations have always given satisfaction in every respect.

Mr. Craik, of Hamakua Mill, brings up the point of electric arc welding of boiler seams and flues: "Would the annoyance caused by leaky seams and flues be greatly reduced if seams were electric welded after riveting and all flues electric bead welded after being expanded?"

Mr. Craik's question is prompted by his own experience in repairing some boilers by this method and I quote from his letter in regard to same:

We had considerable trouble with two of our 7x20 boilers, which leaked badly at the first and second course circumferential seams and flues. It is history that these boilers always did leak at the seams and flues since they were installed new, during the close season of 1923.

Every "move on the board" was tried by skilled boilermakers to repair the leaky seams and flues. The loose rivets were cut out, riveted, the seams carefully caulked, and the boilers retubed. Each boiler successfully stood a water test of 150 pounds, but when steaming they again developed leaks, more serious than ever, at the same seams and also at the flues.

Enough tubes were removed to allow a skilled welder to work inside and the faulty seams were electric welded inside and outside to almost the waterline. The flues were bead welded after being expanded and beaded in the usual manner.

Since this electric welding work was done two years ago we have had no trouble whatever with these boilers.

Mr. Daniels, of Pioneer Mill, brings to our attention a method of handling excess bagasse when the fireroom gets filled. He states that they installed an 8-inch blower driven by a 5 h. p. motor at 3065 r. p. m. to blow their surplus trash over into a vacant lot 200 feet away. The blower was fed automatically by a chute connected to the main carrier. At the end of the grinding season all the low grades were boiled off, using this trash as fuel by blowing this pile of approximately 200,000 cu. ft. back to the fire room, through a 16-inch pipe with an 18-inch blower driven by a 50 h. p. motor at 2,100 r. p. m.

Not many plantations are blessed with this extra amount of fuel but the above suggests a method of solving the problem if one is not prepared to bale the trash. Pioneer Mill intends installing a press in the future.

The above suggests the fact that Wailuku Sugar Company have a blower installed in their carpenter shop for handling their sawdust and it is their intention to blow same over to their fire room to help out the fuel problem.

Mr. Duncan, of Olaa, in his letter gives his experience in securing a heavier blanket over the grate bars by a change in the angle of same. As he also brings up points for discussion, in connection with the burning of molasses, we quote here as follows:

The only change we have made this year has been to lower the angle of the furnace grate bars from 50 degrees to 40 degrees from the horizontal. Owing to this steep angle the bagasse would slide to the bottom of the furnace, forming a heavy blanket there and gradually thin out at the top. It was impossible to keep the excess air to a minimum, on account of this light blanket being sucked off the grate and up the smokestack before combustion had taken place. Since changing the angle there is now quite a heavy blanket at the top before it starts to slide to the bottom. In this way the boilers can be forced when the necessity arises without losing everything lying on the grates, combustion taking place when it should.

One considerable source of trouble we are experiencing is the excessive amount of clinker forming on the furnace walls and on the top of the bridge wall, for about three feet into the so-called combustion chamber.

All of our molasses is burned by spraying it on the bagasse as it leaves the last mill, and, as we all know, it is the molasses which is the cause of the clinker. We have also tried burning it with the use of a burner, similar to an oil burner, but with no better results. I think a little discussion on the subject of the proper method of burning molasses would be beneficial. I am aware that several mills are burning their molasses in a separate furnace, using no bagasse, but a few interesting points for discussion would be:

What is the advantage of this method over that of burning molasses and bagasse together?

Is the total heat recovery greater or less by this method than the combined method?

What percentage of the total steam is generated by the molasses alone?

Mr. Johnson, of Wailuku, states, in connection with burning molasses, that they "have been experimenting to some extent on burning waste molasses in conjunction with bagasse." They have found "that by applying the molasses, heated to about 140 degrees F., in a fine spray over the bagasse as it leaves the last mill" they "experience very little difficulty in the furnaces with clinkers or burnt grate bars." The writer is also aware that in other factories where molasses is mixed with the bagasse before burning, there is less trouble with clinker if there is an opportunity for the molasses to become well mixed with the trash before reaching the furnace.

Mr. Anderson, of Papaikou, states that they have had an ample supply of trash during the past season and attributes this, in a certain measure, to the cleaning of the boilers. The following is from his letter which also gives the method of cleaning the outside of the tubes in the off season:

The thorough removal of ashes at the end of the week has a lot to do with the conditions of the following week. We steam down our boilers on Saturday and the removal of the ashes and clinker we have let to a contractor who supplies the men and sees that the work is done as required. I would say that the contract is the most satisfactory method of cleaning boilers.

The cleaning of the boilers (externally) in the off-season is a job that usually takes up a lot time, and a job that the men do not like. Last off-season I fitted up a sandblast and applied it to do the cleaning, and I got very good results.

The tubes were cleaned much better than when done by hand, and with a few bent pieces of pipe it was possible to reach in places where the hand could not. I consider that this saved a lot of time, several men, and we had a better job when finished.

Another thing which helps the fuel situation is an even running of the mill. A mill that is running on a high tonnage of cane per hour and then shut down for lack of cane, is harder on the trash pile than when it is running a little slower and can keep going.

Mr. Dunn, of Honomu, writes that the only addition to fire room equipment is the installation of a boiler feed water filter. This filter was designed by Mr. Dunn and consists of two identical units which can be used in series, in parallel or singly. This allows of one unit being cut out and the filtering medium changed without shutting down the whole installation. The filtering medium used is excelsior, which is contained between perforated plates, one top and one bottom forming a cartridge which can be lifted out bodily for changing.

Mr. Dunn also calls attention to a safety device, which he describes, for recording water levels in boilers, and he also suggests a method of placing buck-stays in the masonry of a boiler setting. The following referring to the foregoing is taken from his letter:

I do not know whether the following is in line with the subject of your report, as I have not, to date, had the opportunity of demonstrating it, but it was brought to my attention a short time ago, and appealed to me very strongly, as an important factor in boiler room equipment. I have in mind an instrument, which I believe has recently been placed on the market, for recording water levels in boilers. To give you a definite idea of what the inventor claims for his device I will quote from his article:

"The instrument makes a written record of the height of the water in the boiler throughout the 24 hours, and in addition rings a bell whenever the level is either too high or too low. A mechanically operated pen draws a red ink line on a circular, clock-driven chart, and this record indicates graphically all the important facts which need be known regarding the care the boiler is receiving. The red line shows exact time when boiler was 'cut in' and 'cut out', when it was banked for the night, when it was 'blown off', and when in operation. Foam in the boiler actuates the bell signal in the same way as would low water, and the ringing will continue until this undesirable condition is corrected. The water gauge is illuminated sufficiently to make its markings visible 50 ft. away."

If such an instrument will do all the inventor claims, it will minimize dangers in steam boiler operation, and lower insurance rate materially.

Personally, I think such a device is almost a necessity, particularly where unskilled operators are employed.

It has been the writer's experience that, the conventional method of placing buck stays in the masonry of boiler setting is erroneous, due to the fact that many of the stays become burned out and broken, and can not be replaced without tearing down the brick-work surrounding the stays.

To eliminate these conditions the writer suggests that buck stays be placed in conducts. This would prevent, in a measure, the breakage of stays, as it would afford an air circulation around the stays, and offers an easy method to make replacements when necessary, at a minimum cost.

Mr. Hughes, of Hawaiian Commercial and Sugar Company, offers the following interesting contribution, and as it touches on many points which should be of interest to all, his reply is given in full as follows:

During the past season, operations were carried on without the use of oil as extra fuel, this being an improvement here over previous years' work.

This improvement we attribute to the burning of waste molasses; changes in the furnaces, which have allowed a more efficient combustion of the bagasse; converting two oil burning furnaces into bagasse furnaces, thereby adding two 300 H. P. boilers to the high pressure steam line; saving of heat due to the Petree Process eliminating the mud press station, and saving of heat due to the Dorr Clarifiers. A brief description of these different points will be of interest.

When extra fuel was required we used molasses in conjunction with the bagasse. Owing to the limited space available for the storage of surplus bagasse fuel, and there being objections to blowing and storing it outside the mill building, we did not accumulate as much surplus as we might have. This surplus could, in turn, have been used for drying-off purposes at the end of the season, but during this period wood and molasses were used.

This extra fuel was required only when the following conditions prevailed:

When grinding at a very low rate of speed, so that an insufficient supply of bagasse entered the furnaces, stoppages due to no cane, breakdown delays, choking of the mills due to the large quantity of juice and mud returned to the mills from the clarification system, and the polishing of the rollers while Petree Processing.

Six furnaces were arranged with molasses burners, and, when required, any number of these furnaces could be supplied with molasses as extra fuel. These furnaces are of the regular bagasse or Dutch oven type.

A small amount of bagasse is fed into the furnaces, about one-third of the quantity that would be used when firing with bagasse alone, while the molasses was fired through the burner from the front end directly above the fire-box. Live steam is used to atomize the molasses and exhaust for heating it to a temperature of 170° F., a pressure of 75 lbs. being maintained at the burner.

The molasses burner used is a simple combination of pipes, arranged similar to that commonly used for oil burning, provided with a distributer head to which the steam and molasses piping is connected.

The boiler tubes were blown out with a steam hose every eight hours, to remove the deposit of potash which was finally collected at the flue uptake, a door being provided for that purpose.

When all available bagasse storage space was filled with surplus bagasse, an outside electrical load of 300 K. W. to 600 K. W. was taken over by the mill plant in addition to the regular mill load. This extra load was taken care of regardless of the amount of cane on hand, and throughout Sunday shutdowns, the load dropping considerably on Sundays. While carrying this extra load, and the mill grinding at the rate of 110 to 120 tons of cane an hour, it became necessary at times to open up a 12″ exhaust valve to the atmosphere in order to use up steam. With the grinding rate in excess of 95 tons an hour molasses would not be required.

A change in all the bagasse burning furnace grates proved to be a beneficial one. Bagasse, when fed into the furnace, takes the shape of a long thin wedge, with the sharp end lying at the top of the step ladder grates. At this point the layer of fuel is very light, and a good draft quickly removed the fuel from the grates, thereby allowing the air to short circuit through this space, while the heavier layers of fuel lower down in the furnace remained a smoldering mass until the upper grates became covered again.

To remedy this condition, the air spaces between the slanting, or step ladder grates, were blanked off at the upper end, to prevent dislodgment of the thin layer of fuel at this point. The floor, or flat grate area, was increased in proportion to the decrease in area of the step ladder grate. The free space, or space between the floor grates, was

considerably increased, as was the space under these grates, this being done to prevent the accumulation of ash under the floor grates from blocking off the air passageway.

We found this to be a great improvement. The bagasse burned freely and evenly, maintaining a higher and more uniform temperature as well as a more uniform record of CO_2, indicating a more efficient combustion of the fuel.

Two 300 H. P. boilers with a combined heating surface of 6,345 square feet, formerly equipped with oil burning furnaces, and used as boosters whenever the demand for additional steam warranted, were added to the high pressure line as live units, as continuous generators, by changing the furnaces to the bagasse burning type. With this change made, we removed all oil burners, likewise the temptation to open up the oil, which the firemen had become so accustomed to doing that they thought it was impossible to get along without it.

The Dorr Clarifier and Petree Process are responsible for a great saving of fuel, by their eliminating the mud press and filter press stations. We had thirteen 34" frame mud presses in operation, and eight 34" frame clarified juice filter presses, which, with their large radiating surfaces and hundreds of draw-off cocks, liberated a tremendous amount of heat. The clarified juice now enters the first cell of the evaporators at an increase of 18 to 20° F., over the old system. The immense benefit from the wonderfully improved clarification was reflected in the boiling of both commercial and low grade sugars. All sugars dried more rapidly and with less effort, this being especially noticeable in handling the low grades, so it is clearly obvious that a considerable saving of steam was effected here.

The Peck Strainer is without a doubt responsible for a good share of the saving at this station, by the strainer removing practically all the cush-cush from the juice before liming and heating takes place. The strainer removes a large percentage of very fine bagasse that would pass through a 100-mesh screen, indicating that the cake of cush-cush deposited on the periphery of the screen acts as a very fine filtering medium. All this cush-cush removed by the strainer is returned to the mills and adds to the fuel supply.

Here, the Peck Strainer and the Dorr Clarifier were installed in the same season, and it would only be a wide guess to say how much of a saving in fuel either one, or the other, is responsible for.

The Uehling indicating and recording CO_2 intsruments have given much more satisfactory service this past season, due to the installation of a small and inexpensive filtering device that screws on the end of the sampling tube. This device consists of two carborundum discs about ½"x4" in diameter, bolted through the center and held in a suitable frame. All the gas drawn through the sampling tube must filter through these two discs, and the gas lines are kept free of ash.

We have installed in the fireroom this season, our second Alberger centrifugal boiler feed pump. This is a duplicate of the one now in use, which is a four stage turbine-driven pump that has given excellent service at an extremely low cost for upkeep and repair.

Other replies were received but had nothing particular to report. Many others were not heard from. Lack of time may have been the reason in many of these cases, but it is hoped that this paper will have something of interest to all mill engineers, and that they will have had opportunity to read it and be prepared to discuss the various questions brought up.

Miscellaneous Reports of the Chemical Section*

Compiled by S. S. Peck †

In the absence of the Chairman of the Chemical Section of the Association of Hawaiian Sugar Technologists, I beg to announce that several very interesting reports were received as contributions to our annual meeting. Unfortunately, owing to unforeseen difficulties and lack of time, these reports could not be published in full, but I am presenting their salient features, calling attention to the valuable points brought out, together with a summary of results.

Raymond Elliott contributed a very interesting report on the cane borer injury, in which he presents the results of a very thorough investigation, conducted by himself at Paauhau. Representative quantities of cane were cut from whole fields, the sticks then divided into groups according to whether they were sound, borer-infected, or with or without rat injury. The writer kept a count of the rat-eaten cane as well, in order to ascertain whether there was any connection between rat-eaten cane and the borer injury.

Mr. Elliott reports an average of 28% infestation by borer on the quantity of cane examined of all varieties, the infestation of the different varieties being as follows: Yellow Caledonia 34%, H 109 29%, D 1135 9%. Two percent overall was found to be both rat-eaten, and borer-injured.

To emphasize the damage wrought by these pests, Mr. Elliott calls attention to the fact that the quality ratio has increased on an average from 7.78 to 12.85 over all experiments conducted on Caledonia and H 109 canes. Computing the loss in dollars and cents, it amounts to 1.9% on sugar per acre, or 17.3% in actual money.

F. D. Bolte reported on the subject of "Influence of Lime on Boilinghouse Purities," which report is all the more valuable because it represents actual working conditions throughout a number of years.

The tabulated results show the following interesting facts: The lime used per ton cane was increased from 1.07 lbs. during 1915-1921 inclusive, to 1.26 lbs. in 1922-23. Correspondingly, the increase in purity rose from .58 to 1.75, but, on the other hand, the drop in purity from No. 2 massecuite to No. 2 molasses, and from No. 3 massecuite to No. 3 molasses decreased from 12.8 to 8.7 and 10.2 to 8.5 respectively, giving a higher gravity purity waste molasses for 1922-23 than previously, i.e. 42.3 against 40.5. The amount of lime used did not seem to affect the drop of purity in the first boilings. In enclosed tables Mr. Bolte shows the relationship between the quantity of lime used and the corresponding change in purity from year to year, also the averages for the periods together with the final molasses figures. The boilinghouse recovery and efficiency

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† Acting Chairman, Chemical Section.

figures are also given, showing 2.49% increase in recovery for one degree increase in purity, and 3.37% for 2 degrees increase, figuring on the same gravity purity molasses.

In his recapitulation, Mr. Bolte strikes the keynote of his report when he says that while it is better to use too much lime than too little, it is best to use just the right quantity. The correct amount appears to be about 1.20 lbs. per ton cane, varying with the acidity of the juice, and the kind of lime used, giving a slight alkalinity to red litmus paper on hot clarified juice, corresponding to .15% acidity against phenol and N/28 KOH solution, using 1.5 cc. of it to titrate 10 cc. of the juice.

Mr. H. F. Hadfield contributed a report on "Clarification," and it is rather unfortunate that this could not be published in full. After defining the term "clarification," and describing the process with its attendant chemical and physical changes, Mr. Hadfield emphasizes the importance of correct liming, dwelling on the methods in use for determining acidity and alkalinity as a guidance to liming. The great importance of heating the limed juice to the right temperature and for the right length of time is then mentioned, calling attention to the fact, that there is apt to to be a variation in the precipitation and the subsequent rate of settling. The character of the impurities, and their relation to the sugar in solution is pointed out, with reference to the viscosity of the massecuites and molasses.

The much discussed topic as to the poor filterability of Hawaiian sugars is next mentioned. It seems to be the general opinion that this is directly due to neglect in clarification, and the presence of suspended solids in the juice. The writer quotes Messrs. Peck, Welle of Crockett, and Prinsen Geerligs on the subject, the essence of which is, that finely divided solid matters held in suspension, when heated with lime, will change into a hydrolized gummy matter, enter the solution, and go through the whole process. In each of the quotations, emphasis is laid on the importance of the removal of these suspended particles from the juice by screening. Kopke's turbidimeter was found to be a useful instrument for the measurement of the brightness of the clarified juice.

Tests on 96° sugars show .06 to .005% suspended matter. It was surprising to find, that practically the same quantity of suspended matter was found in plantation white sugars polarizing 98°-99°. In determining the suspended particles in juices and sugars, the writer found the Vaccu-filter very convenient, in fact superior to the Gooch crucible.

Experiments show, that raw sugar contains suspended particles not only in the adhering molasses, but also within the crystal itself. This seems to confirm the theory, that sugar from a supersaturated solution of dirty syrup is apt to crystallize around a minute particle of fiber or suspended matter, and build up the crystal around it.

In screening the clarified juice or syrup, one should not lose sight of the fact that the wear on the screen, due to both mechanical causes and the corrosive action of the juice is great, and on at least one occasion the writer has found, that greater amounts of particles than usual were getting into the sugar, because the perforations of the screen were worn to three times the original size. The usual 1C0x100 mesh screen apparently will not keep out the very fine particles

of fiber; to partly overcome this difficulty a 200x200 mesh screen will be of great help. This 200x200 screen is apt to get clogged up if it is used alone, but in conjunction with the 100x100 screen, or rather supplementing it, it should keep clear.

Reviewing the process in the refineries, the writer, quoting from Mr. Welle, finds that the experience in the refineries is the same as in our own factories, i.e. the suspended particles still remain in the sugar after purging the sugars with affination syrup. Upon being melted, the crystals liberated the occluded particles, the whole forming a brown, dirty looking liquid. These melts are then mixed with kieselguhr, and filtered through presses under pressure. It is at this point that the trouble is experienced, because with most of our sugars it sometimes takes 3 to 4 times more kieselguhr, to keep the rate of filtration within the allowable time limit, than with foreign sugars. Strange as it may seem, the soluble non-sugars remain practically the same before and after filtration.

We all know that press juice contains no suspended particles. This suggests that filtering the whole clarified juice through filter presses may solve the difficulty. But the question arises here as to whether this is within the scope of our factory policy or not.

The questionnaire sent out to various members of the Association brought out the following points:

1. The strainers used at the mills varied in size from 9 to 100 mesh, or from 64 to 225 holes per square inch; subsequently the mixed juice contained between .12 and .68% of suspended particles.

2. On clarified juice 50 and 100 mesh screens were used, and the percent suspended matter in the commercial sugar was found to be between .07 and .005. Nobody has tried 200x200 screens.

3. Those who screened the cold mixed juice over a 100 mesh screen, find the mud slimy, but this difficulty was largely overcome by overliming the mud.

4. Several of the factories add lime to the mud, the press-juice being returned either to the mixed juice or clarified juice.

5. All agreed that at 190° F. the juices settled poorly, while at 240° F. the juices foamed in the settlers and took longer to settle.

6. All agreed that slow drying of low grades was mostly due to poor clarification.

7. Replies indicate that no relationship between season and quality of low grade sugar was found.

8. Mr. King at Koloa found a consistent relation between the clarity of juice and its phosphoric acid content, but no relation in the rate of settling. Lower fields contained more phosphoric acid than did the upper ones. Phosphoric acid variables in different varieties of cane affected the clarification differently.

In conclusion, Mr. Hadfield wishes to thank all the members who assisted him with contributions to his report.

A most complete report was sent in by V. Marcallino entitled "Blank Boiling," the subject being treated in a very thorough fashion. The contributed data and information will no doubt be very valuable to those practicing blank boiling. The salient results, as indicated by the answers sent in to the questionnaire, are given below in a systematic manner:

1. The only treatment the molasses receives before string-proof boiling is steaming. with the object of dissolving the fine grain which might be present and which otherwise

would cause trouble in the subsequent purging. In connection with this, the writer refers to Prinsen Geerligs' book *"Cane Sugar and Its Manufacture."*

2. The molasses from which blank boiling is done should be reduced to 51-56 purity; with this initial purity two boilings will be required to obtain a satisfactory final molasses of say 38 gravity purity, the last boiling to start with at least a 40-44 purity. A table of purities submitted by Mr. Bolte, from Hutchinson, shows the best results from 1916, when starting with a syrup purity of 88.6 a final molasses of 39.65 was obtained, the intermediate low-grade purities being as follows: No. 2, 52.03; No. 3, 42.26. A table of Waiakea results for the past three years is also given.

3. The answers sent in seem to indicate that there is no advantage of boiling back molasses under 40 purity; the drying becomes slower, the yield smaller, and besides, it becomes a question of storage tanks and centrifugal capacity.

4. As to the density to which low grades should be boiled, the limits of concentration as indicated by the answers are 90 to 96, depending on local conditions. Here the writer again quotes Prinsen Geerligs.

5. With a decreasing purity of the last massecuite, an increasing density is desirable to obtain a goodly crop of crystals.

6. In regard to the temperature at which the low grade boilings should take place, this ranges between 138 and 155° F., with a corresponding vacuum.

7. In almost every case, the massecuite is discharged at the temperature at which it was boiled.

8. Only a very few members had experience with the brasmoscope as an aid to boiling, though without doubt it is a valuable instrument. Mr. Marcallino calls attention to Bulletin No. 20, of the H. S. P. A. Experiment Station, in which Noel Deerr describes this instrument.

9. None of the factories practicing blank boilings use recording vacuum and temperature gauges, though their value is universally recognized.

10. No one has reported any experience with the refractometer, and Mr. Marcallino again quotes Noel Deerr in his *"Cane Sugar."*

11. Opinion is divided regarding the rate of cooling. Most seem to agree that speeding up the cooling tends to produce false and small grain.

12. The average temperature at which the massecuite is sent to the mixer is about 86° F., some reporting as low as 77, some as high as 104.

13. How many days after boiling is this temperature reached? In the case of No. 2 this is about 3-10 days, in No. 3 about 6-7 weeks, and in No. 4 about 3 months. (Answers to this question seem to indicate the length of time before drying rather than the number of days required to reach the questioned temperature.)

14. Opinion differs as to whether crystallization is complete at the above-mentioned temperature (86° F.), some stating that the crystals will keep on growing thereafter.

15. Tables and graphs submitted by Messrs. Elliott and Bolte show the drop in temperature day by day for different types and sizes of cooling tanks.

16. Replies indicate that in small or flat iron containers the cooling and crystallization proceeds more rapidly than in big or wooden tanks.

17. All the members who have contributed, recognize the disadvantage of discharging successive strikes into the same tanks; the result is uneven grain, and of course the rate of cooling is slower.

18. All agree that each strike should be dried separately.

19. The practice of partially cooling each strike in separate tanks, say for one week, and then pumping it into larger tanks for further crystallization, is advantageous from the grain standpoint, according to Messrs. Spreckels, Bolte, and Marcallino.

20. Opinion divides as to the harmful effect of slow discharging of the massecuite from the pan. Some believe that no grain forms in a string-proof strike for the first few hours at least, others find that if the massecuite chills, false grain forms.

21. Answers to the question, "What is the result when the massecuite flows slowly through long gutters and pipes?" are the same as in paragraph No. 20.

22. Foaming is caused, in most cases, by boiling at high temperatures, sometimes on account of overliming. The preventative is obvious, and no one suggests a cure.

Mr. Marcallino again quotes Prinsen Geerligs on the subject.

23. In order to prevent foaming, the boiling temperature should not exceed 155° F., though the exact limit is not known.

24. If a massecuite is unavoidably overheated during boiling, cooling it down in the pan before discharging is not always a remedy.

25. Nothing definite can be said regarding the drying qualities of a foamed over massecuite.

26. When boiling string-proof, the size and character of the resulting grain may be controlled to a certain extent by regulating the density; a heavy strike as a rule will yield a thicker crop of crystals, and a correspondingly lower molasses.

27. All members agree that a better exhausted molasses can be gained from fine grained than from coarse grained massecuite.

28. As a general rule, low grade massecuites which dry slower yield a lower purity waste molasses, provided the slow drying was not caused by mixed or false grain. In the latter case, grain escaping through the screen will make for higher molasses. With equal purities, and grains of a similar size and character, that massecuite which is more concentrated will dry slower and will yield the better exhausted molasses.

29. Opinions differ as to the length of time for complete crystallization. It depends largely upon individual equipment. This question was already touched upon in paragraph No. 13.

30. The appearance of grain in the pan before striking, either by accident or by intention, ought to be avoided in low grade strikes to be cooled at rest.

31. Regarding inversion, it is a well known fact that in most factories the molasses products have an acid reaction, for the purpose of obtaining some idea of the degree of acidity, Mr. Marcallino describes a method for determining the acidity.

32. Actual loss due to inversion, during storage of massecuite, is reported by two members, though it is noted that it is extremely difficult to obtain a representative sample from a large tank of massecuite at the time of drying, for the reason, that the sugar tends to settle to the bottom while the top is foamy. Mr. Elliott presents some very interesting tables on No. 2 and No. 3 massecuites held in storage; there appears to be no deterioration in his case.

33. In answer to the question, "What are the causes of slow drying?" the members have the following to offer: High density, high viscosity, excessive small grain, low purity, foamy massecuite, too much lime, too cold massecuite.

34. To aid drying, the following special practices are noted: Reducing the density with water before drying; adding hot molasses before pumping the massecuite to the mixer; steaming it a little, and using a small amount of water in drying.

35. The available sq. ft. of screen surface per ton cane per hour for string-proof massecuites varies from 2.6 as the lowest, to 7.86 as the highest, a wide variation.

36. Opinions differ as to whether there is any advantage of boiling to say 95, and then diluting to 92, as compared with boiling to 92 and not diluting. Of course, it is known that in the case of heavily concentrated massecuites, the water added will first be taken up by the mother-liquor for the reformation of the hydrated combinations of sugars and salts.

37. The following are the chief causes of a high waste molasses purity: High purity mother-liquor, insufficient concentration, much small grain lost in drying, of water for dilution, low glucose ratio, poor screens, too much lime used, high glucose-ash ratio, unripe cane, insufficient centrifugal capacity, and poor arrangement of low grade tanks. The writer quotes Geerligs on the subject of high molasses.

38. When a refractory low grade massecuite is encountered, its drying qualities may be improved somewhat by allowing it further time to age.

The writer concludes his report with an enclosed calculation from Mr. W. v. H. Duker on required pan and cooling capacities for blank boiling.

The above reports contain some rather extensive tabulations which have not been published, but will be circulated during this meeting.

Finally, your sub-chairmen extend heartfelt thanks to all those who have aided them in compiling these reports, and if some advantage will be derived from their efforts, they will be amply rewarded.

Standardization of Sugar Factory Equipment*

By G. H. W. Barnhart

In Noel Deerr's Circular 17, printed in 1913, an attempt was made to arrive at the necessary capacities for a Standard Factory. Since this publication, conditions have changed and with them requirements have necessarily changed.

Following are the requirements as indicated on three different occasions:

	Noel Deerr	Horace Johnson	William Searby
Boiler Heating Surface (sq. ft.)	500	....	....
Juice Heaters (sq. ft.)	40	30	35
Settling Tanks (cu. ft.)	60	72	72
Filter Presses (sq. ft. filtering area)	100	120	120
Evaporator—Quadruple Effect (sq. ft. H. S.)	225	290	300
Triple Effect	170	215	215
Crystallizers (cu. ft.)	250	362	362
Coolers (cu. ft.)	...	1467	1467
Centrifugals (sq. ft. screen area)			
Shipping Sugars	...	3.0	2.5
Second Sugars	...	4.5	5.0
Total	6.0	7.5	7.5
Vacuum Pans (cu. ft.) (ratio 1:1)	45.0	55.0	60.0
Vacuum Pump Displacement (cu. ft.)			
Quadruple Effect—Dry	8.6		
Triple Effect—Dry	11.5		
Pan (per sq. ft. h. s.)	0.4		

It will be noted that the requirements for evaporators, pans and centrifugals have consistently increased. In a publication by the writer, which is to be printed and distributed to members of the Association of Hawaiian Sugar Technologists, data and some discussion are given covering some of the apparatus mentioned above. For further discussion the reader is referred to the "Report of Committee on Standardization" by W. v. H. Duker, commencing on page 349 of the *Hawaiian Planters' Record,* Volume XXI.

Boiler Heating Surface: So-called standard practice indicates 450 square feet of boiler heating surface per ton of cane ground per hour. Several items affect this figure. First, we have a variation in cane fiber from 9 to 15 per cent.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Other conditions being equal, this indicates a variation of 25 per cent from the average of 12 per cent, and a boiler which operates economically with cane fiber at 12 per cent will be pressed when the fiber approaches 15 per cent. Since the power consumption by the mill varies almost directly as the fiber in cane, it is conceivable that lack of the ideal amount of heating surface may result in insufficient power as the fiber increases. Water-tube boilers are conceded to be more efficient than the fire-tube type, and in calculating boiler horsepower it is allowable to use ten square feet in water-tube and twelve square feet in fire-tube boilers per b. h. p. A third consideration is the economical or practical temperature of the escaping flue gases. A fourth is whether or not there is a surplus of fuel. Finally, the extent to which the "extra use of steam" is practiced in the factory i. e., whether a quadruple effect is used instead of a triple, or a pre-evaporator is used to supply vapors for heating, etc., will determine whether or not the supply of bagasse is ample for all requirements.

Several factories have found it necessary to function with but 70 per cent of the required heating surface, and have been able to maintain operations. This condition has generally resulted in a flue gas temperature in excess of 500° F., which figure is deemed desirable for our conditions. At the same time the increased temperature has resulted in a greater capacity for a given installation. Assuming that 450 square feet of heating surface per t. c. h. will enable the maintaining of a flue gas temperature of 500° F., then, owing to the greater mean temperature difference between the gases and the water in the boiler, when the flue gas temperature rises, the following areas will enable steaming at the same rate:

Temperature Flue Gases	Square Feet Heating Surface	Per Cent
700° F.	283	62.9
650	312	69.2
600	353	78.5
550	395	87.8
500	450	100.0
450	530	117.9
400	676	150.1

The question is, shall we be extravagant with steam in the factory and continually increase the boiler heating surface so as to abstract the last possible heat units from the gases of combustion, and likewise the heating surfaces in the factory so as to utilize all exhaust, striving at the same time for a high CO_2 content, or, shall we economize on steam in the factory, by practicing the extra use of steam, cutting down on the necessary heating surface in heaters, evaporators, and pans, by using higher pressures in the exhaust lines, and, by using less boiler heating surface, obtain a higher rating at a sacrifice in fuel resulting from a higher flue gas temperature? In other words, by using 350 square feet of boiler heating surface per t. c. h., the flue gas temperature would be increased to 604° F., and the evaporation F/A 212° F. per pound of bagasse of 42 per cent moisture would be 2.82 against 3.00 at 500° F., the flue gases having a content of 12 per cent CO_2 in each case, the evaporation per pound of bagasse being 6 per cent less with the higher temperature. A pre-evaporator combination with vapors heating all juices would more than off-set this loss.

Juice Heaters. The maximum capacity in practice, according to Kopke, is sixty pounds of juice per hour per square foot of heating surface, when the juice velocity in tubes is about six feet per second, when the steam pressure in body is four pounds gauge and the juice temperature rise is from 80 to 212° F. This applies to unbaffled heaters. For the baffled type, the capacity is readily 20 per cent in excess of the above. Based on tests and observations the formula for heating surface for baffled heaters has been developed as follows:

$$\text{Sq. Ft. H. S. per T. C. H.} = \frac{R\ T_d\ J}{T_m\ K}$$

where R = constant = 10.23.

T_d = temperature rise in F°.

J = tons of juice per ton of cane (taken at 1.2 for mixed juice and 1.3 for clarified juice).

T_m = the mean temperature difference between juice and steam.

K = decimal figure expressing efficiency of steam with steam at zero gauge as unity. (For each 1 lb. increase or decrease in pressure, increase or decrease this figure 4.4 per cent.)

In this formula T_m and K vary with a change in pressure of steam, and as the exhaust pressure in a factory is reduced, the heating surface must be increased in proportion. For example, lowering the exhaust pressure from 8 to 3 pounds gauge will necessitate increasing the heating surface 70 per cent.

For each 1 per cent of mixed juice on cane above or below 120 per cent, increase or decrease heating surface by 0.83 per cent.

Settling Tanks: Standard practice requires 72 cubic feet per t. c. h. but does not state whether this is to be in three, twelve or twenty tanks, for intermittent settling. Calculation will show that for a given capacity, the greater number of tanks will result in the longest time of settling. Assuming that the time lost, or not available for settling, is equal to 150 per cent of the time required for filling (the additional 50 per cent being required for withdrawing the last clear juices, settlings and scums), then each of the following combinations will give 102 minutes of settling time:

100 cubic feet per t. c. h. in 4 units.
90 cubic feet per t. c. h. in 5 units.
80 cubic feet per t. c. h. in 7 units.
72 cubic feet per t. c. h. in 12 units.

From a cost and labor standpoint we would like to limit the station to four tanks, but this requires a larger unit and total capacity. Suppose, for example, that refractory juices necessitate holding one tank longer than the usual permissible period, then it will be held until its next turn comes. This would leave three tanks in service and the available time would be reduced to about 80 minutes. If 90 cubic feet in five tanks were available and one were isolated, the settling time of the remaining four would be reduced from 102 to 92 minutes; if 80 cubic feet in seven tanks were available and one isolated, the time would be reduced to 98 minutes; and if 72 cubic feet in twelve tanks were available one being isolated, the time would be reduced to about 101 minutes. Obviously, the greater the number of tanks, the less will be the effect on the settling of juices if one happens to be withdrawn from service temporarily.

Evaporators: Reference to the various standards indicates that the heating surface required has been increased gradually from 225 to 300 square feet for a quadruple effect, and that for some conditions 350 square feet would be advisable. Calculations indicate that for every pound that the initial pressure is raised above two pounds gauge, the evaporation is increased 12.5 per cent. Decreasing the syrup Brix to 60 from 70 increases the evaporation 11.5 per cent on an average, the increase being greater at lower initial pressures. Decreasing the vacuum in last cell from 26″ to 25″ will decrease the evaporation 8 per cent on an average, the decrease again being greater at the lower initial pressures.

The table gives the heating surface required under different conditions of initial pressure, syrup density and vacua in last body:

INITIAL PRESSURE	26″ Vacuum in Last Body		24″ Vacuum in Last Body	
GAUGE	13–70 Brix	13–60 Brix	13–70 Brix	13–60 Brix
2	350	303	431	376
3	314	274	376	333
4	282	249	334	298
5	255	228	302	271
6	234	211	274	247
7	216	196	251	228
8	201	182	232	212
9	187	171	215	197
10	175	161	200	184

The foregoing table indicates to what extent the requirements will vary. For a given syrup density and vacuum in the last body, the only factor which must be considered is the initial pressure, and this can be controlled within certain limits.

For each degree above or below 13 Brix of juice going to evaporator, decrease or increase capacity by 1.4 per cent when evaporating to 70 Brix, and by 1.6 per cent when evaporating to 60 Brix. For each 1 per cent of mixed juice above or below 120 per cent, increase or decrease evaporator capacity by 0.83 per cent.

Vacuum Pump Capacities: For vacuum pans, the following quantities of air must be removed per square foot of heating surface by a central vacuum, when the number of pans served and the temperature of injection water is as indicated:

Number of Pans	Temperature of Injunction Water—F°.				
Served	75	80	85	90	95
1	0.40	0.48	0.60	0.79	1.12
2	0.36	0.43	0.54	0.71	1.01
3	0.30	0.36	0.45	0.59	0.84
4	0.24	0.28	0.36	0.47	0.67

For a quadruple effect, the following quantities of air must be removed per t. c. h.:

10.5	12.5	15.0	17.0	20.5

These figures are based on a vacuum of 27″ in a counter current condenser; an evaporation of 20 pounds per square foot in single pans, an average of 18 pounds for two, 15 pounds for three and 12 pounds for four pans; and the evaporation of 1.3 tons of juice at 13 Brix per t. c. h. to 70 Brix at quadruple

effect. The same corrections would be made to pump capacities for a quadruple effect, as for evaporation from a quadruple effect. Since a volumetric efficiency of approximately 67 per cent applies to vacuum pumps under these conditions it will suffice if the figures given are increased 50 per cent. This will give the pump displacement necessary.

Vacuum Pans: Based on an 8-hour cycle for shipping sugar pans and a 16-hour cycle for low grade pans the following capacities are required per t. c. h. when the cane polarization is 14 and gravity purity of syrup varies as below:

	90	88	86	84	82	80	78
Shipping	42.1	41.4	40.8	40.1	39.5	38.7	37.6
Low Grade	12.2	15.6	19.2	22.9	26.8	30.9	35.2
Total	54.3	57.0	60.0	63.0	66.3	69.6	72.8

For shipping sugar strikes, the time of boiling is controlled by the steam pressure available, by the ratio of heating surface to cubical capacity, and by the efficiency of the heating surface. The quantity of this depends on the amount of evaporation which must be accomplished. In pan work the temperature difference, as a strike progresses, is affected by the density of the massecuite, by hydrostatic head, and possibly by other factors, and transmission is diminished by viscosity and lessened circulation. For ordinary work the mean temperature difference with steam at 3 pounds gauge is 32.8° F., and with steam at 8 pounds gauge, is 49.1° F. The efficiencies of steam at 3 and 8 pounds are 115 per cent and 139 per cent respectively, so that the amount of work done bears the ratio of 1 to 1.76. Evidently, where a ratio of heating surface to capacity of 1.2 to 1 is sufficient, when boiling with exhaust slightly under 3 pounds gauge, a ratio of 0.7 to 1 should be just as effective with steam at 8 pounds gauge. This confirms practice to a certain extent, for with the old Stade calandria pans using comparatively high pressure steam, the ratio of heating surface to capacity was generally less than one-half. Inasmuch as the additional heating surface required to bring the ratio of heating surface to capacity up to unity is a very small part of the cost of a pan installation, it seems advisable to provide for at least as many square feet of heating surface as there are cubic feet of capacity.

Crystallizers: It is evident that crystallizer capacity required, depends upon many factors. The approximate formula: $R\ P\ (98 - J)/J$ gives the cubic feet required per T. C. H. where:

$R =$ a constant $= 184$,
$P =$ polarization of cane,
$J =$ gravity purity of syrup,

and where a crystallizer cycle occupies 13 days, final molasses purity = 36, final massecuite purity = 55, second sugar purity = 80, final massecuite Brix = 99, and allowance of 15 per cent is made for foaming, etc. The capacities required are as follows:

Cane Polarization	Syrup Gravity Purity 90	85	80	75
10	164	281	414	564
12	196	338	496	676
14	229	394	579	790
16	266	450	661	902

The approximate figure of 400 cubic feet, now used, corresponds to a polarization of 14 and a syrup purity of 84.8. A more exact formula has been developed which reads as follows:

$$\text{Cu. Ft. per T. C. H.} = \frac{3\ \text{PDH} \times (S - J)\ (s - M)}{J \times (s - j)\ (S - M)}$$

in which P = cane polarization,

D = number of days in crystallizer cycle (including time for filling, emptying and cleaning),

H = number of hours factory grinds per week,

S = gravity purity of shipping sugar,

J = gravity purity of syrup,

M = gravity purity of final molasses,

s = gravity purity of second sugar,

j = gravity purity of second massecuite.

The purity of second massecuite will depend upon the method of boiling in the factory. Purity of second sugar will depend upon the density of final massecuite, and upon the number of centrifugals and cycle of operation. Necessary crystallizer cycle will depend upon the individual juices. J varies according to condition of cane, fertilizer used, time of year cane is harvested, etc.

Centrifugals: Allowing a 10-minute cycle for shipping sugars, a 60-minute cycle for low grades, and 6.5 cubic feet per charge when using a 40″x24″ machine, the following capacity will be required in machines per t. c. h. when cane polarizes 14:

	Gravity Purity of Syrup 90	88	86	84	82	80	78
Shipping Sugar	0.1348	0.1328	0.1308	0.1284	0.1263	0.1239	0.1211
Low Grades	0.1087	0.1375	0.1690	0.2015	0.2355	0.2720	0.3092
Total	0.2435	0.2703	0.2998	0.3299	0.3618	0.3959	0.4303

The corresponding screen area would be:

Shipping Sugar	2.845	2.805	2.760	2.710	2.666	2.612	2.555
Low Grades	2.292	2.901	3.568	4.250	4.970	5.745	6.530
Total	5.137	5.706	6.328	6.960	7.636	8.357	9.085

It will be noted that there is a very close agreement between standard and theoretical for 82 purity syrup and 14 polarization in cane.

The foregoing is an attempt to present standards for certain of our cane sugar factory equipment which can be adopted and used in comparing the equipment of factories handling cane juices of very different characteristics.

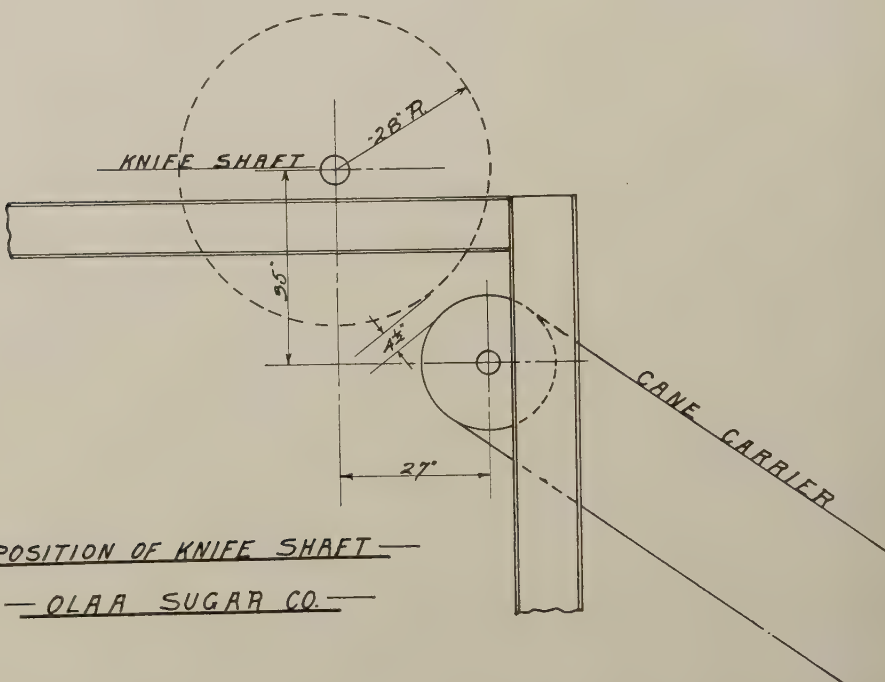
Mill Equipment*

BY G. H. W. BARNHART.

As Chairman of the Committee on Mill Equipment. I have the following report to present to the Association of Hawaiian Sugar Technologists. Replies to a questionnaire sent out at a rather late date have been very encouraging and representative.

George Duncan, of Olaa, writes as follows regarding a set of revolving knives on which he has been working for some time:

Before this installation we were troubled very much with both our revolving knives and hubs breaking and causing considerable damage to the first mill rolls. As we have no crusher at Olaa, the cane has to be cut very short so as to eliminate trouble at the shredder. As will be seen from this sketch, although the tips of

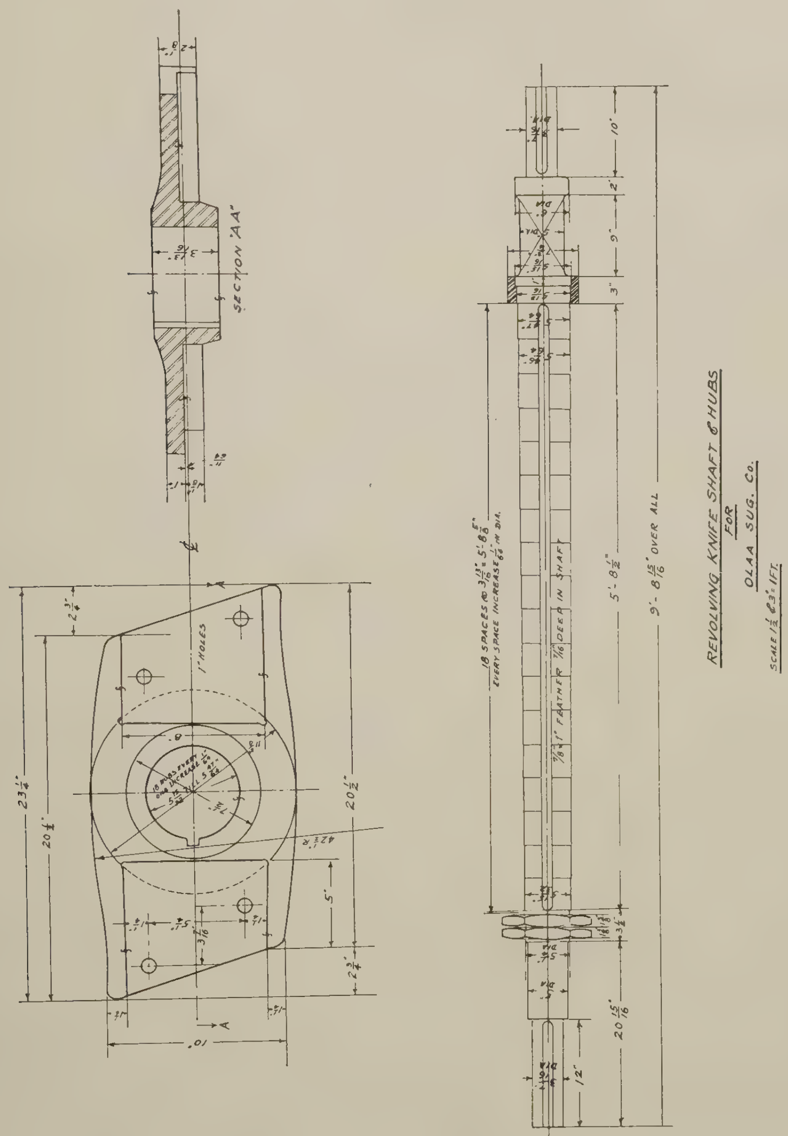


POSITION OF KNIFE SHAFT
OLAA SUGAR CO.

the knives are 4½" from the carrier, the cane is cut as short, or shorter, than if the knives were placed directly over the carrier. To eliminate excessive strain on the knives and hubs, a change in construction was necessary. The sketch shows the hub and shaft of the new arrangement. The part of the hub into which the knife is inserted is tapered, the bolt holes being drilled 1" in diameter. The knife is carefully machined to fit the hub, but the bolt holes are drilled 1⅛" diameter. When the knife is placed in the hub it is driven outward by a steel wedge until it is practically solid in the hub. The wedge is left to hold the knife in place, and is kept from falling out by a ½" steel plate, which fits over it and into the knife recess. This plate serves the purpose of holding the wedge in position, supports the knife on the side opposite the hub proper, and prevents the hub from being worn away by the action of the cane coming into contact with it.

*Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Since this installation our revolving knife trouble has been about eliminated.



A new crusher feeder has been in use at Pioneer Mill during the past year and a half. This was developed by Chief Engineer Edmund Daniels, out of a caterpillar crank shaft which was made to operate three arms, each having two cross-arms which traveled upward under the crusher chute and on the return movement engaged the cane in a positive feed. This device was found to be far more satisfactory than the usual star or finger pusher. The crank shaft was made to revolve 10 times to each 3 of the crusher roll.

More and more of the factories are finding it advantageous to separate the crusher and first mill, owing to the impossibility of obtaining a good feed when handling canes, some of which are hard and others soft. Makaweli plans the

installation, in the near future, of a separate engine to drive the crusher and cane carrier. A further improvement at this factory is the deepening of the cane carrier pit, and lowering the carrier so that the cane unloaded from the cars will tend to distribute itself and pack on the carrier, producing a more even and regular feed at the crusher.

Improvements inaugurated in 1919 at Waipahu were not entirely effective until the 1923 crop was taken off, on account of the strike in 1920 and the labor shortage. Both trains now consist of a set of knives, Krajewski crusher, Searby Shredder and 12-roller mill. Comparisons of records while making the installations of the new equipment indicate the Searby Shredder to be responsible for an increase of 1-1.25 per cent in extraction.

The installation of Meinecke intermediate carriers at Ewa has been reported as eliminating practically all delays due to breakage of slats and chain. Ramsay macerating scrapers, while satisfactory in effecting a better absorption of maceration water, are still objected to on account of the large amount of bagasse which must be cleaned out by hand when the mill has shut down.

Secondary strainers, of which there are two generally efficient types in use, are being thoroughly covered by another committee.

A satisfactory substitute has apparently been found for the objectionable juice strainers which, up to the present time, have been a necessary evil in the mill. This substitute is the Unstrained Juice Pump, so named because it handles the combined juice and cush-cush from the mill without its having first been passed through a screen to separate the cush-cush. Open runner centrifugal pumps, screw pumps, air and steam ejector lifts have been used in an attempt to solve this difficulty without satisfactory results. Besides causing the scrapping of the most objectionable piece of equipment from a factory standpoint, the Unstrained Juice Pump should enable a more efficient use of the dilution applied, since a considerable portion of the last mill juice is now "entrained" by the cush-cush from this mill and others in the train and carried back to the first mill without having done any useful work whatever. The trial at Waipahu, where one of these pumps handles the juices from the last two mills of "A" train, was successful. A perforated apron distributor with revolving wooden slats was used for returning the maceration juice and cush-cush over the intermediate carrier.

Most of the factory operators are now aware of the difficulties resulting from the use of feed water, for boilers, which has not been properly treated. Oil, and other foreign matter in steam, has been found to be at the bottom of the majority of the troubles in boilers, boiler tubes, and equipment using this "impure" steam. Feedwater filtering apparatus and oil separators are gradually being installed to eliminate as much as possible of the foreign matter in exhaust steam.

Copper and brass piping and fittings for mill juices are bound to come into general use. The high cost of labor and material for replacing these lines each season, with many cases of inter-season changes, are demonstrating the wisdom of the installation of these lines even though the first cost may be high. The same applies to monel metal cloth for screens.

Three factories have installed high speed vacuum pumps of the Ingersoll-Rand type during the past year. Wherever installed, these pumps are doing good

work, maintaining the necessary high vacuum with a minimum of steam consumption. Some of the smaller factories have found it advantageous to install sugar bins large enough to hold the night sugar, all of the bagging being done by the day shift. Other factories have attained the same result by retaining all night massecuite in special crystallizers, drying and bagging being done only by the day shift. The saving in labor in either case is obvious.

The demand for a higher purity second sugar, and a lower purity final molasses, together with the unusually low syrup purities during the last four seasons has given impetus to the installation of more crystallizer and centrifugal capacity. Lihue has increased its crystallizer 33 per cent, its centrifugal capacity 40 per cent, and a molasses purity of 34.96 for 1923 speaks well for the additional equipment. Kekaha has replaced a considerable number of small tanks and coolers with 16 - 800 cu. ft. crystallizers, the new installation showing a great improvement over the old cooler system in labor, efficiency and technique. Wailuku is installing 6 U-shaped crystallizers. Makaweli reports the addition of 6 - 40″ W. D. MacIntosh centrifugals with dischargers. As was usual with a labor saving device, the operators did not at first take kindly to the dischargers, but since using them and becoming reconciled to them, they would not do without them now. These dischargers are time-saving as well as being easier on the men. Wailuku Sugar Company also reports the addition of 6-40″ machines.

Olaa's installation of a 45-ton pan with 1800 sq. ft. of heating surface, has rounded out the factory equipment so that it can handle all the cane as it comes and still maintain a satisfactory grain in shipping sugars. A 35-ton calandria pan is going in at Wailuku.

A high speed 20″x32″ Nordberg-Todd Poppit Valve Uniflow Engine connected direct to a 300 k.w. A. C. Generator for Wailuku Sugar Company, emphasizes the breaking away from the generally accepted practice of installing turbo-generators for supplying electric power for mills. A similar installation made at Waimanalo was in use during the 1923 crop. While no figures are at hand, it is understood that the steam consumption of the uniflow engine is appreciably lower than that of a turbine or the Corliss engine, and this installation fits in very well where it is desired to cut down on quantity of exhaust steam produced.

The installation of a 175 H.P. motor connected direct to a Cameron 4-Stage centrifugal pump for Wailuku, is also mentioned for the coming crop. While its function is not mentioned, it is hazarded that the water is for driving water-driven centrifugals.

The above completes the information received covering new equipment already installed or being installed.

Among the devices to make the path of the operator an easier one may be mentioned the following:

Safety device on Crusher: A simple electric gong alarm was rigged on the top roll bearing of the primary crusher at Wailuku, so that when the top roll rose above normal feed level a circuit was closed that rang the gong. This warned the man at the cane carrier, and the mill crew, that iron, or other foreign material,

was going through the crusher. This reliable and prompt warning enabled the stopping of the mill before the iron could get to it and do any damage.

Hinged Slats in Cane Carrier: Owing to fine bits of cane and trash packing together in the cane carrier roller chain so that the rollers could not function, it was found, at Wailuku, that hinging two slats at equal distances apart on the carrier so that they would hang when on the bottom travel, permitted the fine particles to drop out at the lower end of the carrier so that no further packing was experienced.

The two slats swing back into place as the carrier's flight, of which they were a part, started over the bottom sprockets on the upward travel.

Continuous Liming Device: C. J. Fleener, of Waipahu, writes that a continuous liming device, perfected at Waipahu, was described in the *Hawaiian Planters' Record* for July, 1923. This is, undoubtedly, the simplest and best liming apparatus on the market.

Mud Stirrers: Many factories are finding it difficult to form a press cake after passing the mill juices through a 100-mesh screen. Kahuku has demonstrated for its own condition, that sufficient liming of the settlings will enable the formation of a perfect cake. It is quite probable that the main difficulty lies in the uneven liming of the settlings. Waipahu is installing two mud tanks which will take the place of the usual "blow up" tanks. In each of these the impeller of a discarded pump will be rotated to insure a perfect distribution of the lime added. The tanks are cylindrical in shape and are arranged with baffles and a central downtake, so that the course of the settlings and lime, while mixing, will be up the walls of the tank and down the center well to the impeller. The baffles are included to prevent the formation of a "vortex" which would retard the rate of mixing.

Koloa reports the use of "sour molasses" and compressed air for "boiling out" evaporators during the 1923 crop, with a saving of 50 per cent in the cost of cleaning. One of the low-grade tanks was fitted up to act as a fermenting tank and the liquor was drawn in through a 3″ line by vacuum. Compressed air was admitted through the evaporator doors by means of conveniently arranged ½″ pipes. An alteration and extension to the sugar bag conveyor now permits the loading of bagged sugar on the cars with a minimum of labor.

Lihue reports that it was customary to boil low grade strikes to 99 brix or denser, prior to 1923, but that due to the long time required in discharging and to the necessity for dilution later on, it was found advisable to boil to 97 only. This speeded up the discharge from the pans, the massecuite handled more easily, and drying was made possible without the addition of any water. Instead of a raise in purity being noted, a drop of a full point was obtained.

James Donald, of Kekaha Sugar Company, writes as follows:

> Our most baffling problem, and one we have never solved, is to obtain accurate weights of cane and juice, and samples of these, particularly cane, which are truly representative of the whole. Calculating from juice back to cane, and vice versa, the results seldom agree and are frequently so divergent as to throw doubt on the whole factory control.
>
> An important factor in this state of affairs is the personal one, the reliability of the operator, where the scales are not automatic. As compared with the class of labor we had a few years ago, the men now available show an exasperating indifference to the quality

of their work, and are concerned only in filling in their time somehow. An automatic counter is not of much assistance, and some device or system is needed which will keep a check on the work of the weighers. In regard to the juice weights, I am inclined to believe that a V-notch, or other type of measuring weir with accurate recording and sampling arrangements, would yield more reliable weights than scales, although I cannot speak from experience.

Another important factor is the constantly changing quantity and *nature* of the foreign matter in the cane cars.

It seems hopeless to attempt to arrive at the quantity of ''trash'' (which includes soil, stones, sticks, dead cane, diseased and rotten cane, rat- and borer-eaten cane, green leaves, dead leaves, etc.) by stripping an occasional car, and the cost of stripping a sufficient proportion of cars to yield a useful correction is prohibitive in these days of scarce, expensive, and inefficient labor. It has been suggested from time to time in the past to weigh the bagasse, and I believe that this question should now be taken up seriously and thrashed out to one conclusion or another. This would give us another check on cane weights and juice weights.

An even better check would be the weighing, or measuring by accurate recording apparatus, of the syrup. This should be done in any case, and if the mixed juice weights are reliable it will be a potent factor in localizing the undetermined losses.

Mr. Giacommetti writes very briefly that the most perplexing problem at Olaa is the prevention of the formation of false grain after the massecuites have left the pans, thus preventing a satisfactory "exhaustion" of final molasses.

The problem of driving a battery of centrifugals by a Corliss engine, and of operating the engine at a speed which was economical of steam, was one which confronted A. G. Barker of Honokaa at the end of the 1923 crop. With the pressure in the boiling house reduced to 70 lbs., and the speed of centrifugals fixed, the problem was one of determining the speed at which the engine would deliver the required horsepower and still be economical of steam, and then arranging the pulley ratios so that the centrifugals would operate at the required speed.

At a speed of 46 r.p.m. the engine delivered 105 h.p. and "failed to cut-off for at least 50 per cent of the time." The operation was very irregular at times, due to "hunting", and the steam consumption was out of proportion to the power delivered. A rough rule for cane sugar factory practice is that the m.e.p. at which the steam consumption will be a minimum is about 40 per cent of the throttle pressure. Applying this, and taking into account material on hand, an engine speed of 65.5 r.p.m. was adopted. "At this engine speed there will be available 42 per cent more power than at 46 r.p.m.; the operation will be more regular, due to the engine cutting-off at all times during normal operation, and the consumption of steam will be much less."

Electrification*

By H. G. Purcell

Cane sugar factories resemble other industrial plants, especially those which generate their own power and use steam in the process of manufacture. Therefore, the same problem confronts the executive, that is, the simplest method of obtaining the finished product with the least expense.

Concentration of power generation in one plant close to the boiler-room is, in itself, a considerable measure of economy, in that power is generated on a more efficient basis in a large unit and the expense and heat losses incidental to long steam lines is avoided.

With electric drive it is possible to effect economies in building construction due to the comparatively light weight of motors, the small space used and the ease of running electric power circuits to any part of the mill. Machines may be located exactly where they are best suited to the process of manufacture, without regard to the question of drive, and attendance can be reduced to a minimum, as control devices automatically protect the motors and the machines they drive.

Besides performing that part of the work for which it is designed, the machinery of a sugar factory also acts as a reducing valve to supply steam to the boiling-house at the proper pressure, and the simplest method of performing this part of the cycle is the most desirable.

The steam consumption of mill engines and other large units is usually quite satisfactory, but direct-acting steam pumps and small steam engines are inefficient, even when in the best mechanical condition. A duplex pump uses from six to ten times as much steam per horsepower per hour as a Corliss engine or steam turbine.

The electrical equipment of a sugar mill may be divided into two parts, the power station and the factory.

The usual power house installation consists of one or more turbo-generators ranging in size from 300 to 1,500 KW., supplying 3 phase current at 440 volts and 60 cycles. While the turbine seems to be the most popular type of prime mover, Corliss engines are also used and one plantation is installing a Uniflow engine. In a series of articles in *Power,* not long ago, S. H. Mortensen of the Allis Chalmers Co., compared turbine-driven and engine-driven generators, referring especially to Corliss engines in sizes most suitable for sugar mill work. The principle advantages of engine-driven units are their simple design, with easy access to all parts; large slow-moving bearings which are easily lubricated; good ventilation; and low peripheral speeds which tend to reduce collector ring trouble. The advantages of turbo-alternators are the small space required; high efficiency and close regulation, being especially adapted to operating in parallel with other machines, and for supplying current to synchronous motors.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Under conditions found in the average mill there is not a great difference in the economy of the three types of prime mover previously mentioned. Using saturated steam at 125 lbs. gauge pressure, and with 4 lbs. back pressure the water rate of a Corliss engine is 26 to 28 lbs. per horsepower per hour, steam turbine 23 to 25, and Uniflow engine 22 lbs. The following figures were taken from a test of a Uniflow engine at the Hoover Vacuum Sweeper Co.:

Steam pressure	140	lbs.
Superheat	100	deg.
R. P. M.	200	
Back pressure	1.9	lbs.
Steam consumption	19	lbs. per h. p. hr.

With saturated steam and more back pressure, the water rate of this engine would undoubtedly be much higher.

In Hawaiian sugar mills the application of motors has not been extended to the crushing plant as it has in Cuba, but they are to be found in most of the other stations throughout the factory, operating conveyors, mixers, pumps, etc.

The importance of properly applying motors and motor control to pumps cannot be appreciated without realizing the dependence of the sugar factory upon this particular type of apparatus. The problem of selecting a motor for a specific pumping application involves careful consideration of the starting and running characteristics of the pump, and the service required.

Owing to the construction of the plunger pump, with tightly packed stuffing boxes and sliding pistons, the initial breakaway torque may equal 125 to 250 per cent of normal full load torque, depending on the mechanical condition of the pump. Immediately upon starting, the pump delivers full capacity per stroke, with the result that full load torque is required for the remainder of the starting period unless the pump is equipped with a by-pass or some means of relieving the pressure until the motor is up to speed.

The running characteristics of this type of pump are simple. A positive amount of water is delivered with each stroke, and the power requirements vary directly with the speed or pressure.

The action of a rotary pump resembles that of a multi-cylinder reciprocating pump, except that there is less friction and the starting torque is much lower.

The centrifugal pump differs from the two foregoing types in both starting and running characteristics. The average centrifugal pump requires about 30 per cent of full load torque at starting, and if the discharge valve is left closed during the starting period, only 50 to 60 per cent of full load torque is required when the motor reaches full speed.

The following general rules apply to centrifugal pumps:

1. The head varies as the square of the speed.
2. The quantity varies directly with the speed.
3. The horsepower varies as the cube of the speed.

With alternating current, the following capacities and types of motors are recommended for the different kinds of pumps:

For plunger pumps, squirrel-cage motors up to 5 h. p., as they can be thrown directly on the line. For larger sizes, wound-rotor motors should be used as

they will develop adequate starting torque without drawing excessive line current.

For rotary pumps, squirrel-cage motors are frequently used in sizes up to 50 h. p.

For centrifugal pumps, it is permissible to use squirrel-cage motors up to 500 h. p. For installations requiring constant-speed motors of 75 h. p. or over, the synchronous type of machine is often used because of the power-factor correction possible, even though it draws as much starting power as a squirrel-cage motor.

This is an important point, especially in a plant where the motors are not always fully loaded. Low power factor is due to lagging current drawn from the line by inductive loads, such as induction motors, arc lamps, etc., and its disadvantages are generally known to power users.

Improvement in power factor can be effected by the application of a synchronous machine which would operate as a power factor correcting motor, that is, part of the input would be used for energy and part for furnishing leading current to the line. The capacity of the motor and its location in the factory would be determined by local conditions.

Unloader	10 h. p. motor
Unloader and Car Haul	20 " "
Shredder	300 " "
Lillie Evaporator (quadruple)	100 " "
Vacuum Pump (17x10 twin)	30 " "
Maceration Pumps	3 " "
Standard Drain Pumps	2 " "
Knives	75 to 100 h. p. motor
Mill Pumps	75 to 100 " "
Juice Pumps	10 to 25 " "
Bag Washer	10 to 15 " "
Crystallizers	10 to 15 " "
Centrifugals—	
40″ Machines (8)	100 h. p. motor
30″ " (16) Low Grade	50 " "
30″ " (12) " "	30 " "
30″ " (21) " "	25 " "
30″ " (8) " "	15 " "

During the grinding season this year, time element relays, which ring a bell at the crusher station if either knife motor becomes overloaded, were installed in the motor controls on both knife sets.

This warning enables the operator to slow down the cane-carrier in time to avoid jamming the knives and stalling the motor. Since this system has been adopted, there has been a substantial increase in cane tonnage and no stops to clear the knives.

Report of the Committee on Grooving*

By O. R. Olsen

As chairman of the Committee on Grooving, I respectfully submit the following:

I addressed letters and questions to twenty mill engineers, and received but six replies, which are incorporated in this report.

J. W. Carmichael, of Hawaiian Sugar Co.:

I don't know that I have very much to say on grooving that is new, unless it is that I believe in coarse grooving for the first and second mills, and fine grooving for the third and fourth mills, say 7 grooves to the inch. This arrangement has worked satisfactorily here, both in extraction, moisture, and a closer setting of rollers.

One other thing I might mention is in connection with the juice grooves of feed and back rollers, and that is to have them straddle. In other words, the first groove on the feed roller would be 2″ from the end, while the first groove on the back roller would be 3″ from the end, with the following grooves spaced 2″ apart.

E. Daniels, of Pioneer Mill Co.:

We have no juice grooves on the back roller of our first mill, but the grooves are deep enough to drain the juice without the juice grooves. This method has been applied as the Puunene standard.

In my opinion, the coarse grooving on feed rollers with diagonal grooves, feed better with close mill setting, as it avoids regrooving during the season.

R. E. Hughes, of Puunene Mill:

To establish some sort of a standard here, in both the Messchaert and surface grooving of rollers, the grooving now in use was decided upon several years ago, after considerable experimental work had been done to determine just what would be the best groove to suit our conditions.

Before the introduction of the Messchaert groove and the Searby Shredder, the practice of changing the surface grooving of this, that and the other mill, was common, with very little noticeable change in the quality of the work. Our standard was arrived at gradually, and completed early in the year 1918. Since that time we have made no changes in the grooving, following as closely as possible our standard, which is as follows:

MILLS OPERATING WITH SEARBY SHREDDERS

First Mills: All first mill rollers are grooved to mesh, pitch of surface grooves ¾″, feed roller Messchaert grooved 2¼″ pitch, when new 9/32″ wide and 2¼″ deep. No Messchaert groove scrapers are used on the returner bars. One set of scrapers at the bottom of the roller. No Messchaert grooves in the discharge rollers.

Second Mills: Feed rollers are grooved ¾″ pitch, Messchaert grooved 2¼″ pitch, 9/32″ wide by 2¼″ deep. One set of Messchaert scrapers are fitted under this roller. Top roller surface grooved 8 to the inch. Discharge rollers surface grooved 8 to the inch. Messchaert grooved 2″ pitch, 9/32″ wide by 1¾″ deep. One set of scrapers fitted to, and resting on lower blade of the Ramsay scraper, with a second set below the roller.

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Third Mills: Feed and top rollers grooved same as second mill. Discharge roller surface grooved 8 to the inch. Messchaert grooved 4" pitch, 9/32" wide and 1¾" deep. Scrapers arranged same as second mill.

Fourth Mills: Feed rollers grooved same as second mill. Top same as second mill. Discharge rollers surface grooved 8 to the inch. Messchaert grooves 2" pitch, 9/32" wide, 1¾" deep. Two sets of Messchaert scrapers are fitted below the Ramsay scraper. All bagasse from these two sets is returned to the same mill in a dry condition by scroll conveyor.

Operating with this arrangement of grooving, we have had excellent results in extraction, low moisture in the final bagasse, and no difficulties with the feeding of the mills.

To insure a maximum efficiency from the Messchaert grooves, they should be deep enough to allow for rapid and unobstructed drainage of the juice, yet not so deep as to weaken or shorten the life of the roller. If the bagasse is allowed to press down to the bottom of the groove, the mill might do as well without any Messchaert grooves. The same can be said of the groove when it is not scraped clean with each revolution of the rollers.

Our first mill rollers were grooved with the ¾" pitch groove soon after the installation of the Searby shredders. These take hold of the shredded cane and feed under all conditions or rates of grinding, and allow a very fine drainage way for the expressed juices.

Our last step in completing our standardization of the roller grooves, consisted of the fitting up of all the mills with a feed roller of ¾" pitch. This change improved the feeding of the mills to such an extent that we were able to slow down the mills, thereby operating with a heavier blanket of cane and obtaining a higher extraction.

A ¾" pitch grooved roller, with Messchaert grooves of 2¼" inch pitch, when placed in the fourth mill of a twelve-roller train as a feed roller, will tend to reduce the moisture in the final bagasse.

The surface of these coarse grooved feed rollers improves as the grinding proceeds, the juice action tending to rough up the surface, so that it soon becomes a mass of very small teeth.

It has been our experience that wear and breakage with this groove is no greater than with any other.

A good percentage of large pieces of iron, such as car pins and links which find their way into the mill, are removed at the crushers, as the hydraulic accumulators indicate immediately the presence of any hard material. If any does get by, it is heard passing through the shredder, and an effort is made to remove it before entering the mill rollers; not all, by any means, being recovered, a fact that is substantiated by the condition of some of the rollers at the end of a season.

We have made some very interesting, and from all appearances successful, acetylene repairs to some of our rollers that were broken down on the side of the Messchaert groove, or broken away at the extreme end of the roller. The broken down parts were at first quickly heated with a large oil torch, and the space welded or filled in with Tobin Bronze. The weld in every case, from all appearances, after machining and grooving is a good one. Bronze was used so that it would not be necessary to heat the roller to a very high temperature, thereby eliminating to some extent the chances of cracking the roller, as it is welded while on the shaft.

We do not expect the bronze to resist wear as well as the iron, but we do look for less Messchaert groove scraper trouble, and thereby add one more little item that should make for a smoother and more efficient operating mill.

In answer to questions relative to juice grooves in first mill feed roller, and juice grooves in other rollers of various pitches, the following replies were received:

W. A. Kinney, of Waialua Agricultural Co.:

During the 1923 crop we did use juice grooving in the feed roller of the first mill. The juice grooves in the other rollers are of various pitches, due more or less to old rollers.

We have standardized on 25 juice grooves 3/16″ wide by 1¾″ deep. The grooving of the first and second mills for the 1923 crop was changed.

First mill: Feed rollers—¾″ pitch. Top roller—⅜″ pitch. Back roller—⅜″ pitch.

Second mill: Feed roller—⅜″ pitch. Top roller—¾″ pitch. Back roller—¾″ pitch.

This has proved very satisfactory. We are using the original style of juice groove scrapers.

Iron seldom gets beyond the crusher, but of course when it does, it plays havoc with our juice grooves. A hydraulic alarm is used on the crusher.

J. L. Renton, of Ewa Plantation Co.:

It is our intention to install the ¾″ pitch feed steel roller in the second mill this off-season for trial next crop.

We are gradually changing the pitch of our top and back roller grooving from ⅜″ to 3/16″ pitch. Before the advent of the Messchaert grooving, I believed the coarse grooving a help, both in feeding and juice extraction, but with the Messchaert grooves we have gradually gone back to a finer grooving with equal results.

George Duncan, of Olaa Sugar Co.:

Previous to the campaign just finished, all of our rollers were grooved 6 to the inch. At the end of last year it was decided to groove the feed rollers ¾″ pitch, which grooving we used all this year. Very little, if any, advantage was observed from the use of them. They were very easily damaged by tramp iron, consequently the turner bar grooves were also damaged. This resulted in frequent breakage of the turner bar hook bolts. The juice grooves also wore away at the sides very quickly, this probably being caused by the bagasse becoming wedged tighter into them, helped by the wide ¾″ groove at the top.

This year we intend to change the pitch to ⅜″. Several years ago we used this size grooving and very little trouble was experienced, even from iron getting into the mill.

I think large grooves, i.e., about ¾″ pitch, are detrimental to the roller. The only advantage to be gained from them as far as I can find, is heavy feeding, but this can be quite as easily obtained from grooves about ⅜″ pitch. The life of the roller is considerably shortened by the large grooves, and every plantation is not in a position to purchase new ones every two or three years. I think, therefore, before recommending such coarse grooving that due consideration should be given to local conditions.

At Lihue mill, the writer wishes to say that a coarse grooved ¾″ pitch feed roller was installed in the first mill in 1919, and this roller is still in operation, but as feed roller in the second mill, and we expect at least a couple of years more service from it. The rest of the rollers were of fine grooving, and we experienced considerable trouble in feeding.

For the 1922 crop, we grooved the feed rollers of mills No. 2, 3 and 4 with ⅜″ pitch grooves, and obtained better results in feeding.

For the 1923 crop, we equipped the first mill with ¾″ pitch grooved rollers, and the second and third mills with feed rollers of ¾″ pitch grooving. As we had no suitable roller for coarse grooving, at that time, for the fourth mill, we retained the ⅜″ pitch feed roller. All the other rollers in mills No. 2, 3 and 4 were grooved 7 to the inch. Our feed troubles ended in the mills equipped with coarse grooved rollers, but we continued having trouble in feeding the fourth mill.

This year we are installing a ¾″ pitch grooved feed roller in the fourth mill. Iron, in the shape of car links, pins, etc., find its way into the mill, and is first noticed when passing through the shredder. An attempt is made to get it before it enters the rollers, but very seldom are we fortunate enough to get it before the

first mill. We generally find it between the first and second mills, but at times some gets by.

We have had no trouble with the returner bars or hook bolts breaking, through iron entering the mill.

The grooving on the first mill rollers was considerably damaged by iron, and we were obliged to regroove the top roller once during the crop.

A single set of juice groove scrapers is used on all the feed rollers, with no scrapers on the returner bar toes. The back rollers are equipped with juice groove scrapers resting on the lower Ramsey scraper, and one set below the roller, with the exception of the fourth mill, which has two sets of scrapers below the roller scraper.

In conclusion, I wish to thank the following gentlemen for data furnished of their respective mills: E. Daniels, R. E. Hughes, J. W. Carmichael, Geo. Duncan, J. L. Renton and W. A. Kinney.

Machine Shop Equipment*

By J. L. Renton

This is a new subject and one that can be made of much interest to the engineers.

Buildings: There are several modern machine shop buildings on the various plantations, such as those at H. C. & S., Paia, Lihue, Oahu, Ewa, and possibly others with which I am not acquainted. The accurate work required from a shop demands a well lighted building, and this feature has been mastered and excellent results obtained by the installation of sash and skylight. Mr. Taylor of H. C. & S. says he thinks a shop in this country should never be built with skylights as the glare is too bright and warm.

The writer is of the opinion that the metal sash without skylights is the best, as sufficient light is admitted and the air that is available by opening the sash makes for an airy and cool work room. As far as light alone is concerned, the skylight arrangement at Oahu Sugar Co. cannot be improved, and ventilation is obtained by large doors and some sash.

Lihue Plantation leads all others in the location of its shop, which is served by the same electric crane which covers the mill. The transfer of heavy mill machinery to the shop is a simple matter, and much time and labor is saved.

All of the five above-mentioned shops have fully electrified cranes.

Tools: No set list of tools for plantation requirements can be made though there are some tools that all plantation shops must have. It is only the larger plantations that can branch out into a more or less special tool instead of duplicating what is already on hand. No discussion of lathes, drill presses, shapers,

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pipe machines, or grinders will be attempted, as all plantations have all of them, excepting some which probably substitute a planer for the shaper.

The advantages of the open side planer for plantation use are evident when most of the new planers installed are of this construction.

Key-seaters, slotters and heavy presses are necessary where rollers are assembled. Several plantations have small hydraulic presses. An arbor press which would soon pay for itself, is very inexpensive and powerful, being useful even in a small shop.

Present day pipe machines will thread bolts, easily making a bolt machine unnecessary except on the larger plantations.

All shops, no matter how small, should have a power-driven saw, as it is a labor saver and in use most of the time.

The power-driven punching and shearing machine is a necessity to all large shops.

Mr. Bourne, shop foreman at Ewa, reports that he does not know how we ever got along without the power punch and shear, and that one should be on every plantation regardless of size. This machine has been in constant use since erection, on practically only repairs necessary to upkeep of equipment, and no new work done. This work would have had to be done somehow and indicates a great saving in time and labor.

Several shops report a milling machine. At the new shop at Ewa Plantation, a horizontal boring, milling and drilling machine was recently installed, and is being watched with considerable interest. Mr. Bourne reports: "I believe this to be the only one of its kind on a plantation in the territory. Its worth as a general utility tool on plantation work was demonstrated the first month it was in operation. It has been put to use boring cylinders, boring journal boxes of all kinds, including mill roller journals and main engine bearings, besides milling all key-ways. It is extremely easy to set up, with adjustable power feeds and quick return in all directions, all of which is easily handled with accuracy and speed."

Plate rollers are useful, especially to the irrigated plantations.

Mr. Taylor of H. C. & S. reports: "We have just completed a pipe 39″ in diameter and over two hundred feet long made of 3/16″ plate, all of which was electrically welded. When we tested the pipe we didn't have a single leak. We saved a great deal of time, labor, and material on this job."

Most plantations are equipped with compressed air and the necessary tools, also gas and electric welding outfits. They pay for themselves in labor saved and material reclaimed that would otherwise be lost.

Jigs and Fixtures: This topic can be made intensely interesting to the engineer, as a means of interchanging useful information. There are innumerable like parts made in quantity on the plantations, and when an engineer finds an easier way to make these duplicate parts, the method of so doing would be welcomed by all mill engineers and shop foreman. Such parts as shredder hammers, leveler knives, chain links, scraper toes, etc., are samples of such duplicate parts.

Mr. Olsen reports on grooving rollers and scraper toes as follows:

A little jig of the same principle as the milling machine index head, was worked out here and attached to the feed screw of the roller lathe. It is operated with ratchet and lever, and in changing from one groove to another, the boy pulls out a pin and operates the lever until the proper distance has been reached, when the pin drops in again. We have done away with all the delays of time lost, due to measuring, etc. This jig worked so satisfactorily on our coarse grooving and fine grooving, that I equipped the large shaper and small planer with the same rig, and now I can groove my returner bar toes and scrapers in half the time, and know they will fit the roller grooving when finished.

Mr. Duncan, of Olaa, also has a like jig for grooving returner bar toes in the shaper. He sent in a photo of his shaper machining the jaws of a mill housing, which I am sorry I can not include in this report but have it for those who would be interested in seeing it. I would recommend the following title for the photos: "Where there is a will there is a way."

Brass Foundry: Paia has the largest and probably the best plantation brass foundry in the Islands. With fuel oil and compressed air available, any plantation could build a crucible melting furnace for small brass parts and save money by utilizing the scrap brass available.

Tinsmith Tools: Few plantations report having any but the simplest tinsmith tools. It is wonderful what excellent work is turned out by some of our employees with a soldering iron and a few pieces of scrap. Tools would make the parts more quickly, if not any better, at a saving in labor and time.

Tool Room: Practically all engineers report the same. Bins, shelves, racks or pins for every tool, and a place for every tool. All men drawing tools from the tool room are furnished with checks (or bangos) and deposit one for every tool drawn, in most cases the check being placed in the compartment vacated by the drawn tool. This is as simple and as accurate as any system and works out well. Usually, all tools must be returned to the tool room Saturday night, to be drawn out again if needed.

Two tool rooms report drill grinders, but the writer believes there are others who neglected to report.

Salvage: This department can always pay for itself and the more systematized it becomes the greater will be the returns.

Waialua, Oahu, and Olaa report reclamation warehouses. The writer has visited the one at Oahu Sugar Co., and commends it highly as an example for plantations desiring to install a system of this sort. The entire building (of moderate size) is given over to reclamation of salvage, with a man there continually. The attendant is given other work and when not thus occupied does reclamation work. Bins and boxes are provided for material, through this warehouse.

In conclusion the writer would like to call attention to the matter of "Labor Saving." Under our present conditions this is a topic for serious thought, and if a piece of machinery will save labor it should be considered also in that light.

Electric cranes, arbor presses, power saws, power punches and shears, air tool, gas welding, electric welding, and tinsmith tools have all been mentioned in this report as labor saving devices, and the field has not been half covered.

The scope of this report is very general and leaves the more detailed reports and general discussion for subsequent papers.

Report of the Committee on Juice Preservation*

By L. W. Howard

From the small number of replies that I received and the greater number that I did not receive, I am forced to believe that other phases of the sugar industry have been more thoroughly investigated and experimented with the last year than the line upon which I requested information. I am therefore obliged to recapitulate more or less in order to present any report at all.

Mill Sanitation

This is a phase of the subject that has received considerable attention during the last few years, special effort being made to overcome some of the losses that have occurred around the mill, juice strainers, troughs and tanks.

The deterioration of very dilute acid juices, we all know, is very rapid. Its rate of inversion is also increased by the presence of sour, slimy accumulations, invariably found around the mill checks, returner bars, bolts, or other places where unless exceptional care is taken in cleaning the mill, their presence will not be discovered.

We have not, as yet, determined how far a loss can be traced directly to that condition, but there is no doubt that there is a great loss.

Juice pans, troughs, and strainer slats are probably accountable for a great deal of this. A possible remedy would be to replace wooden slats, which become saturated with juice, by slats of angle iron. A fiber or fabric edge could be placed upon the scraping edge of the angle iron.

Usually, the troughs or piping under the juice strainers are in some inaccessible place and are, therefore, seldom if ever, cleaned. Some provision should be made for steaming them thoroughly at regular and frequent intervals.

As an inevitable consequence of the increased efficiency of our present day mills, the engineer of today finds himself facing new problems of sanitation. Our modern mills, with their superior double knifing and shredding, have multiplied the amount of cush-cush to be handled; and, these finer particles finding lodgment among the bolts, joints, and crevices, the problem of perfect cleanliness is rendered correspondingly more difficult.

Mr. Pratt, of Lahaina, Maui, reported a very interesting experience with Leuconostoc. It was not due to heavy liming, as it occurred on the way to the juice scales, and not after lime was added. The average of about twenty juice samples, preserved with formalin, showed a decrease in polarization of .32 or slightly over one-half per cent. These were regular samples, and some of them might not have been infected by the Leuconostoc.

Experiments made after adding the bacteria to mixed juice showed that there was practically no loss in either the hot or cold juices in the space of 15

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minutes or half an hour, whether the juices were limed or not. On juice that had stood for three hours, there was considerable loss, greater in hot juices than in cold, and slightly more in alkaline than in acid juice.

Mr. Robbins, of Oahu Sugar Company, reports that they have always felt there was some deterioration in their mill juices before they reached the liming station. One of the causes of this is enlarged mill juice strainers, made imperative by the necessity of separately straining the juices of the third and fourth mills. They are now planning to use a make of juice pump that will enable them to return the juices of these two mills without screening. The only raw juice strained, will then be the mixed juice, and they also hope to eliminate the wooden slats and chains on that strainer.

We are confronted frequently with the problem of accurate analysis of our laboratory samples. Are we not at times deceiving ourselves into thinking that some of our juice analyses are right, when there has been an unobserved, but none the less unmistakable, deterioration taking place?

Mr. Orth, of Ewa, in his answer to my circular letter, enclosed an account of some experiments that he had conducted at the Ewa laboratory with the use of preservatives, for keeping samples without any effect upon sucrose or glucose. I present herein the results of that experiment:

Treated Samples Analyzed After 24 Hours

DRY LEAD ACETATE (Horne's Dry Lead)

Grams per Liter

	Original	12 grams	14 grams	15 grams	16 grams	18 grams
Gravity Purity	85.60	85.42	85.42	85.51	85.51	85.51
Glucose	0.53	0.53	0.53	0.49	0.51	0.51
Glucose Ratio	5.10	5.11	5.11	4.72	4.91	4.91

MERCURIC CHLORIDE

	Original	1 gram	2 grams	3 grams	4 grams	5 grams
Gravity Purity	86.37	85.87	85.99	85.70	86.37	86.37
Glucose	0.61	0.65	0.62	0.59	0.55	0.54
Glucose Ratio	5.50	5.89	5.61	5.36	4.96	4.87

SODIUM BENZOATE

	Original	2 grams	3 grams	5 grams
Gravity Purity......................	87.19	79.21	83.07	81.87
Glucose	0.44	1.01	.69	.75
Glucose Ratio	4.43	11.19	7.29	8.04

TOLUOL (TOLUENE)

50 cc. Toluol per 1,500 cc. Juice

	As Used	After 24 Hours	After 48 Hours	After 72 Hours
Gravity Purity	82.82	80.14	77.52	74.37
Glucose	0.73	1.07	1.41	1.75
Glucose Ratio	7.93	11.99	16.36	21.08

TOLUOL IN COMBINATION WITH SODIUM BENZOATE AND MERCURIC CHLORIDE

25 cc. Toluol per 1,500 cc. Juice

	Orig-inal	Sodium Benzoate 3 grams per Liter 24 Hours	Mercuric Chloride 3 grams per Liter 24 Hours	Sodium Benzoate 3 grams per Liter 48 Hours	Mercuric Chloride 3 grams per Liter 48 Hours
Gravity Purity	80.78	76.18	76.30	73.59	75.37
Glucose	0.98	1.13	1.08	1.54	1.10
Glucose Ratio	10.46	12.53	11.65	17.66	12.02

We note that samples treated with varying amounts of Horne's Dry Lead when analyzed after 24 hours showed a very little change. The samples treated with mercuric chloride of varying amounts, show very little change after 24 hours. The samples treated with Sodium Benzoate show a very great difference, which varies with the increased amount of sodium benzoate used.

The use of Toluol (Toluene) also causes a very rapid change after 24 hours, and Tuluol in combination with Sodium Benzoate and Mercuric Chloride for a like period is responsible for a rapid change.

The question of juice standing over in settling tanks on week-ends or on long, enforced stops brings out some very interesting data. Oahu Sugar Company uses no preservatives in their left-over juice, but they do overlime and heat it to 180° F. They report practically no loss in purity under this treatment.

Mr. Pratt* reports a like method in use at Lahaina, with no drop in purity observed. At Waialua, we have made an analysis of every tank of left-over juice. A sample was obtained from the middle draw-off cock of the settling tanks about an hour after they were filled, and a like sample taken again when the tanks were opened 24 hours later. There was usually a drop of about .8 in purity. The juice that was to remain was overlimed, some formalin added at the liming tank, and the temperature dropped to about 180° F. It has been very satisfactory.

Mr. Hadfield, of the Hilo Sugar Company, adds, as a general rule, 2 or 3 pounds of Carbonate of Soda to 5 tons of raw juice and finds that, although the above quantity is sufficient to keep the juice alkaline until midnight Sunday, the purity drops a point or two.

Mr. Charles Richter reported the use of formalin, at McBryde, which he found usually prevented deterioration. At Kaiwiki, where he substituted for a while during this crop, he continued the use of formalin and also overlimed. He advises the addition of formalin before the juice is pumped into the settlers, making possible a more thorough mixing.

Mr. Giacometti, of Olaa, stated that he believed all tanks, pipes, and containers should be properly cleaned once a week and, if necessary, disinfected. We are all agreed that cleanliness is one of the simpler methods of increasing our recovery and of saving further troubles in the processes.

I am submitting a brief statement made by William L. Owen, research bacteriologist of the Louisiana Sugar Experiment Station, regarding a method for the prevention of deterioration of sugar in storage.

This method will eliminate one of the largest economic losses there is in the manufacture of raw sugars, which is the deterioration in storage. It is estimated that the loss per annum on the normal Cuban crop is $1,500,000.00.

According to Mr. Owen, means have been found for preventing this loss by the inoculation with a certain species of yeast, which acts only on the reducing sugars, producing carbon dioxide and preventing the development of molds, which are the causative agents in producing deterioration. As a result of the action of the yeast on reducing sugars, raw sugars in storage increase in polarization rather than decrease. Mr. Owen is now working out details with a view to the utilization of the method on an industrial scale.

The Miner Laboratories, of Chicago, have reported on a preserving agent that is known as Furfural. The results of their experiments have indicated that the bactericidal action of furfural is comparable with, and the fungicidal actions decidedly superior to, that of formaldehyde. They claim that low concentrations of furfural are not toxic and believe it can be substituted safely and even with decided advantage for formaldehyde in the sugar industry.

I am sure that many of the reports which have been made, or will be presented later at this meeting, will bring out points along the lines of juice preservation, which I have overlooked.

One of our great problems is that of keeping every station in the factory as clean as possible, in order that nothing may enter the process to cause unnecessary inversion, thereby decreasing our recovery or lowering the standard of our product.

A Discussion of the Meaning of the Terms Hydrogen Ion Concentration and P_H Values of Solutions*

By Reginald H. King

During the past decade there has appeared in the literature on sugar manufacture and soil chemistry a term called the pH value of solutions; synonymously with this, a term called the hydrogen ion concentration has been used. Due to the increasing importance being placed upon the reaction, acid or alkaline, of solutions and soil conditions these terms have become exceedingly common and appear in every article. Without a clear and complete understanding of their meaning the essential conclusions to be drawn from experimental data cannot be appreciated or understood. This paper has been written in as elementary a manner as possible in order to clarify any misunderstanding that may exist.

All things must have a beginning; in general their start is in the crude and basic; these terms originated in the elementary principles of chemistry. For a complete exposition it is necessary that the principles of dissociation, chemical reaction, and the fundamental conception of molecular weights be reviewed.

The most elementary, and perhaps the most important, principle to be considered is that of dissociation. By dissociation is meant the behavior of certain substances such as strong acids, bases, and their salts in solution. A salt is a

* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

compound resulting from the neutralization of an acid by a base, viz., sodium chloride, calcium chloride, calcium phosphate, etc. An acid, it may be recalled, is a substance having a sour taste and certain clearly defined properties of producing color changes in substances called indicators. A base is a caustic substance generally thought of as the opposite to an acid in its color-changing property. These substances have certain physical characteristics by which they can be identified, but in solution they have entirely different properties.

A soluble salt when placed in water not only dissolves and disappears but undergoes a decomposition—splitting up into its component parts. This decomposition is known as dissociation. Sodium chloride, for example, dissociates into two component parts, viz., sodium and chloride, but they no longer have the usual physical and chemical properties and are therefore known as *ions,* i. e. sodium-ion, chloride-ion. Hydrochloric acid dissociates into hydrogen ions and chloride ions; calcium hydroxide, a base, into calcium ions and hydroxyl ions. From the foregoing it is seen that the term *ion* is a general one. This should be readily appreciated; all the members of a family have a common name by which the group is known. The individuals in that group have different characteristics, therefore a different Christian name. Think of this term *ion* as the name given to the chemical elements in water. Hydrogen ion means the hydrogen from an acid or other source in water.

In order to be able to measure a thing, or quantity, it is necessary that a definite unchangeable unit be established. A dollar is a definite measurement of wealth; the pound, that of a definite quantity by weight of a substance. It is true that the quantity of any substance in a mixture may be expressed as the percentage of the whole. For example: twenty grams of sugar dissolved in eighty grams of water is a twenty per cent sugar solution. These systems of expressing quantities are of no value in chemical work, in that they do not indicate any self-evident idea concerning the quantities capable of reacting. In order to overcome this inexactness, chemists have devised a system based upon the molecular and normal weights of chemical substances.

All true chemical substances have what is known as a molecular formula, a molecular weight, and a normal weight. The molecular formula for sucrose is $C_{12}H_{22}O_{11}$. This formula indicates that twelve parts of carbon, twenty-two parts of hydrogen and eleven parts of oxygen have been combined by the life processes of the sugar cane. Hydrochloric acid has the formula HCl; one part of hydrogen and one part of chlorine have combined to form the acid. These examples may be multiplied, but these few should suffice to illustrate this idea. These formulae not only signify the chemical nature of the substance, but also give the mass or weight of each element in the compound. In this system, the mass of the hydrogen atom has been considered as unity—all other elements in the atomic state are multiples. For example: hydrogen has an atomic weight of one; chlorine 35.46; carbon 12; calcium 40; etc. This conception of formulae and molecular weights is used in the prepartion of standard reagents; the term *normal* weight is most frequently encountered. This normal weight is not that of twenty-six grams of sugar used in sugar house practice, but is the amount, by weight, of a substance capable of reacting with one gram of hydrogen.

By the term hydrogen ion concentration is meant the concentration of free hydrogen ion in a solution. Free hydrogen ions in excess of free hydroxyl ions produce a condition known as *"acidity"*. From this definition, then, the term implies a quantity, therefore a measurement; for a purpose of comparison, a scale of measurement. Before it is possible to discuss this hydrogen ion scale a clear understanding of the chemical behavior of water is necessary.

Water has certain well-known physical properties with which everyone is familiar; it has chemical properties not so widely known. By very refined methods of analysis it has been found that pure distilled water consists of very large amounts of undissociated water, chemical formula H_2O, and very small amounts of free hydrogen ions and hydroxyl ions. This fact indicates that water dissociates, that is, it undergoes a decomposition. In order to clearly illustrate this fact, as it is of the utmost importance in the understanding of the hydrogen ion concentration scale, an example will be considered with which nearly everyone is familiar.

Pure sugar, sucrose, under certain conditions can be made to decompose into dextrose and levulose. Consider a gram of pure sucrose, by the use of a small amount of hydrochloric acid a very small amount can be decomposed into levulose, which rotates the plane of polarized light to the left, and dextrose which turns the plane to the right. After a very short time the original sugar will contain small amounts of levulose and dextrose, say about .001 grams of each. This is not strictly true; the reducing sugar equivalent of sucrose is 1.05, but for the purpose of this discussion this can be disregarded.

This decomposition being understood, suppose that one gram molecule of sucrose, 242 grams, be dissolved in one thousand cubic centimeters. This is a normal solution, that is, one gram molecule per liter. To this sugar solution a very small amount of hydrochloric acid is added and within a very short time neutralized. Within this very short time there will have been decomposed, say .000,000,1 gram molecule of sucrose and there will have been formed .000,000,1 gram molecules of levulose and .000,000,1 gram molecules of dextrose. The following equation sums up this reaction:

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + \underset{\text{Water}}{H_2O} = \underset{\text{Levulose}}{C_6H_{12}O_6} \quad \underset{\text{Dextrose}}{C_6H_{12}O_6}$$

Water, like sucrose, breaks up to a slight degree but its component parts are ions and carry an electric charge

$$\underset{\text{Water}}{H_2O} \;=\!=\!=\; \underset{\text{Hydrogen ion}}{H} + \underset{\text{Hydroxyl ion}}{\overline{OH}}$$

In the case of the sugar solution this decomposition was static. That is, the sucrose had been definitely changed into levulose and dextrose, they do not recombine. In the case of water this decomposition is not static, but dynamic. That is, the component parts recombine; hydrogen ions combine with hydroxyl ions to form undissociated water.

This decomposition and recombination is constant for any given condition of temperature. In order to indicate this constant quantity the letter K can be introduced as meaning a constant denoting the rate. This equation indicates a

definite mathematical relation; its terms can be multiplied, etc. Multiplying and rewriting:

$$(K) \times (H_2O) = (\overline{OH}) \times (\overset{+}{H})$$

(This equation is a statement of the Mass Law, which requires no explanation in this paper.)

By careful research the values of $\overset{+}{H}$ and $\overline{OH}$ have been found to be .000,000,1 gram molecules per liter.

Since the concentration of $\overset{+}{H}$ and $\overline{OH}$ is so small in proportion to the large amount of the undissociated water, H_2O, the undissociated H_2O can be considered equal to 1. Solving:

$$K = \frac{(\overset{+}{H}) \times (\overline{OH})}{(H_2O)}$$

$$K = \frac{(.000,000,1) \times (.000,000,1)}{1}$$

$$K = .000,000,000,000,01$$

This makes a very unwieldy term to handle in any calculation. In order to simplify, it can be rewritten. Before rewriting, this step should be made clear:

Consider the number......................	.0002
This may be expressed.....................	$\frac{2}{10,000}$
Also as	$\frac{2}{10 \times 10 \times 10 \times 10}$

This expression is infinitely more complicated; in order to simplify, the tens can be given negative exponents and placed above the line, that is in the numerator:

$$\frac{1}{10} \text{ becomes } 1 \times 10^{-1}$$

$$\text{the expression } .0002 \text{ becomes } 2 \times 10^{-4}$$

Using this simplified method of expression K becomes equal to 1×10^{-14}
Substituting this value of K back in the original equation

$$(\overset{+}{H}) \times (\overline{OH}) = 1 \times 10^{-14}$$

This equation states in words that the product, *not the sum,* of the hydrogen ion and hydroxyl ion concentrations in pure water is equal to .000,000,000,01.

From this equation, based upon the dissociation of water, no matter how concentrated the hydroxyl ions may be, there must remain sufficient hydrogen ions to satisfy this relationship. This fact allows the construction of an acidity-alkalinity scale in which the conditions of solutions can be expressed in terms of hydrogen ions. A solution might be exceedingly alkaline but its condition would

be expressed in terms of hydrogen ion concentration. In this scale a hydrogen ion concentration of 1×10^{-7} indicates neutrality; one of 1×10^{-9} alkalinity; and one of 1×10^{-1} extreme acidity.

The terms hydrogen ion concentration and acidity have been used rather interchangeably; this should not be done as there exists a marked difference. A value expressing the hydrogen ion concentration of a solution indicates the intensity, one expressing acidity shows the potential or total amount. For example: consider two boilers, one having a five hundred boiler horse-power per hour rating with a gauge pressure of fifty pounds, the other a much smaller one with a gauge pressure of one hundred pounds. The first, with a smaller pressure, is capable of generating a much greater amount of energy than the other with its one hundred per cent greater pressure. Two solutions having an acid reaction may have the same acidity but entirely different hydrogen ion concentrations, or vice versa. Hydrogen ion concentrations may be likened to gauge pressure, and total acidity to available energy. This distinction between degree or intensity of acidity and total acidity may be expressed in the following manner: Intensity of acidity, is the hydrogen ion concentration; total acidity is the total amount of un-ionized acid which is present in a combined form.

The statement "combined form" leads to a discussion of weak electrolytes, i. e., acids, bases, and their salts that dissociate in solution only to a small degree. Acetic acid, a weak electrolyte, dissociates in the following manner:

$$\underset{\text{Acetic acid}}{HC_2H_3O_2} = \underset{\text{Hydrogen ions}}{\overset{+}{H}} + \underset{\text{Acetate ions}}{\overset{-}{C_2H_3O_2}}$$

This dissociation is constant, and is less than two per cent in a normal solution, that is, the amount of acetate ions and hydrogen ions is less than two per cent of the total acetic acid originally present.

A weak base, such as NH_4OH, dissociates only to about four-tenths of a per cent in a normal solution in the following manner:

$$\underset{\text{Ammonium hydroxide}}{NH_4OH} = \underset{\text{Ammonium ions}}{\overset{+}{NH_4}} + \underset{\text{Hydroxyl ions}}{\overset{-}{OH}}$$

The dissociation of a salt of a weak acid or weak base is exceedingly involved, due to the slight dissociation properties of the acids and bases. For example, the dissociation of ammonium acetate should be:

$$\underset{\text{Ammonium acetate}}{NH_4C_2H_3O_2} = \underset{\text{Ammonium ion}}{\overset{+}{NH_4}} + \underset{\text{Acetate ion}}{\overset{-}{C_2H_3O_2}}$$

But, due to the presence of free hydrogen ions and hydroxyl ions in water, these free NH_4 ions and $C_2H_3O_2$ combine to form the original acid (acetic), and base (ammonium hydroxide). The following equations will illustrate this fact:

$$NH_4C_2H_3O_2 \rightleftharpoons \overset{+}{NH_4} + \overset{-}{C_2H_3O_2}$$

$$\overset{+}{NH_4} + \overset{-}{OH} \rightleftharpoons NH_4OH$$

$$\overset{-}{C_2H_3O_2} + \overset{+}{H} \rightleftharpoons HC_2H_3O_2$$

The sum of these expresses the condition at equilibrium:

$$NH_4C_2H_3O_2 + \overset{+}{H} + \overset{-}{OH} \rightleftharpoons HC_2H_3O_2 + NH_4OH$$

This property of weak electrolytes that suppresses the ionizations of strong acids and bases, with their slight dissociation, is responsible for the difference in the total acidity and the hydrogen ion concentration of solutions which contain them. This fact is distinctly shown in cane juices which contain many weak organic acids and their salts. A sample of a juice which contains malic, oxalic, acetic, citric, succinic acids has a definite hydrogen ion concentration at equilibrium. When a sample of it is titrated, these weak salts, etc., are neutralized and a value expressing the total potential acidity will be obtained which will be greater than the intensity figure.

In order to bring out more clearly this distinction of weak electrolytes, consider the titration of two acids, one strong, HCl, the other weak, acetic. If a .1 normal hydrochloric acid solution and a .1 normal acetic acid solution be separately titrater with .1 normal sodium hydroxide solution until they give a pink color with phenolphthalien, ten c.c. of each acid will require ten c.c. of the base and will therefore have the same acidity. Actually, however, hydrochloric acid is about sixty times as strong as acetic acid, for it is capable of ionizing to a degree sixty times that of acetic acid. During the titration of an acid, as soon as the ionized part of the acid has been removed by the base, a further amount of the previously undissociated acid dissociates. This process is repeated by further additions of base until the whole of the acid originally present has become dissociated, and the hydrogen ions have united with the hydroxyl ions of the base. The next trace of the base reacts with the indicator to produce the pink color.

That the dissociation of electrolytes is also a function of the dilution will be illustrated in the following table:

Dilution in C.C.	Acid % HCl	Acid % HF	Acid % H_2SO_4	Acid % $HC_2H_3O_2$	Base % NH_4OH
1	74.00	7.00	51.00	.40	0.40
10	95.00	10.00	57.00	.13	1.70
100	98.00	25.00	79.00	.50	4.40
1000	99.00	95.00	93.00	1.25	10.20

The figures expressing concentration in the equation:

$$(\overset{+}{H}) \times (\overset{-}{OH}) = 1 \times 10^{-14}$$

must be expressed in gram molecules per 1,000 c.c. From this equation the value of one unknown can be calculated if the other is known. There are, in general, three methods of determining one of these values, they are:

1. Titration (Total acidity);
2. Indicators (Intensity);
3. Hydrogen Electrode (Intensity. Will not be discussed as plantations in the territory are not equipped with hydrogen electrode outfits.)

The titration method is based upon a chemical reaction. For a complete understanding of this important method, the elementary principles of chemical reactions should be clearly understood.

Whenever chemical compounds, acids, bases, and salts react, they react in molecular quantities. A pound of lime cannot be mixed with a pound of sulfuric acid and two pounds of calcium sulfate be obtained. The following equation expresses this reaction:

$$\underset{\text{Lime}}{Ca\,(OH)_2} + \underset{\text{Sulfuric acid}}{H_2SO_4} = \underset{\text{Calcium sulfate}}{CaSO_4} + 2H_2O$$

This means that one molecule of sulfuric acid, molecular weight, $2H + S + 40 = 2 + 32 + 64 = 98$; and one molecule of calcium hydroxide. Molecule weight, $Ca + 2\ (OH) = 40 + 34 = 74$ have reacted, or are capable of reacting, and have produced one molecule of calcium sulfate, molecular weight 136, and two molecules of water. From this it is seen that chemical substances must be taken in proportion to their reacting masses.

The equation expressing the reaction used in the determination of alkalinity is:

$$\underset{\text{Alkalinity}}{NaOH} + \underset{\text{Reagent}}{HCl} = NaCl + H_2O$$

This equation states that one gram molecule of HCl is capable of reacting with one gram molecule of an alkaline substance, $\overline{OH}$, to produce a neutral solution. Whole gram molecules do not necessarily need to be taken; multiples or fractions of these quantities can be used. This is an important principle and is made use of in the use of small amounts of any standard reagent.

A titration is carried out by taking a definite amount of the solution of which the acidity is desired, adding a few drops of an indicator and the standard acid or base solution until a neutral point is reached. Suppose that fifty c.c. of a juice be taken and diluted to approximately one hundred c.c. A few drops of a litmus solution is added and the solution turns red. This indicates that the juice is acid. From a burette, a standard base solution is added until the color of the juice changes to that of pure water to which a like amount of litmus has been added. Suppose that twenty c.c. of a .1 normal NaOH solution was required to produce neutralization. What is the acidity of the juice? This is determined in the following manner: 1000 c.c. of the base solution contains .1 of the normal weight of NaOH, that is 1,000 c.c. is equivalent to .1 gram of hydrogen ion, then:

1 c.c. of base...... .001 grams hydrogen ion
20 cc. of base...... .02 grams hydrogen ion

therefore, since fifty c.c. of the juice is equivalent to .02 grams of hydrogen ion

1,000 c.c. must equal to $\frac{.02}{50} \times 1000 = .0004 \times 1000 = .04$ normal.

Titration gives, as indicated, the total amount present and gives no indication whatsoever of the intensity or the hydrogen ion concentration. This intensity of a solution is obtained by the use of organic dye substances, in solution, that have been standardized with solutions of known intensity.

Certain organic dye substances in solution form colored salts, acids, etc., or undergo intra-molecular arrangement or change in some manner when the hydrogen ion concentration of a solution has a certain value. Below is a list of such indicators; the hydrogen ion concentration range is expressed in grams per liter:

Range	PH	Color Change	Name
.7 to .000,6	.1— 3.2		Methyl Violet
.6 to .0015	.2— 2.8	Red to yellow	Thymol blue
.000,97 to .000,025	.3— 4.6	Yellow to blue	Brom-phenol-blue
.000,0402 to .000,000,996	4.4— 6.0	Red to yellow	Methyl red
.000,0062 to .000,000154	5.2— 6.8	Yellow to purple	Brom-cresol-purple
.000,000,996 to .000,000,02	6.0— 7.6	Yellow to blue	Brom-thymol-blue
.000,000,156, to 000,000,003,96	6.8— 8.4	Yellow to red	Phenol-red
.000,000,062,8 to .000,000,001,56	7.2— 8.8	Yellow to red	Cresol-red
.000,000,009,7 to .000,000,000,25	8.0— 9.6	Yellow to blue	Thymol-blue
.000,000,006,08 to .000,000,000.157	8.2— 9.8	Colorless to red	Cresol-phenolphthalien
.000,000,005 to .000,000,000,098	8.3—10.0	Colorless to pink	**Phenolphthalien**
.000,03 to .000,000,005	4.5— 8.3	Red to blue	**Litmus** (Asolitmun)

The last two indicators are not very sensitive, having a very great range of change.

From the equation developed from the dissociation of water:

$$(\overset{+}{H}) \times (\overset{-}{OH}) = 1 \times 10^{-14}$$

it was shown that a scale could be constructed in which the values would be expressed in terms of grams of hydrogen ions per liter, C_H and that even though the solution be distinctly alkaline this alkalinity could be so expressed. When an acid is added to pure water the hydrogen ions are increased. When a base is added to water the base dissociates, i. e., furnishes $\overset{-}{OH}$ and by this simple process a lowering or shifting of the C_H can be brought about.

Since it is often necessary to tabulate and graph values of hydrogen ion concentrations it is very convenient to have them in the most simple form possible. Values expressed with negative exponents, or decimal fractions exceedingly small, are far from simple. In order to overcome this unwieldiness a manner of simplifying was evolved. To this simplified unit the term P_H was given; its relation to hydrogen ion concentrations is expressed in the following manner:

$$P_H = \text{Log} \frac{1}{C_H}$$

In words, this expression means that the P_H is equal to the logarithm to the base ten of the reciprocal of the hydrogen ion concentration expressed in

grams per liter. In order to illustrate the use of this expression an example will be given.

The strength of a .01 normal hydrochloric acid solution, that is a solution of hydrogen-chloride containing .365 grams of the compound per liter, expressed in terms of hydrogen ion concentration is approximately .0096 gram of hydrogen ion per liter, or 9.16×10^{-3}

$$P_H = \text{Log}\,\frac{1}{9.16 \times 10^{-3}}$$

$$\text{Log}\,\frac{1}{9.16 \times 10^{-3}} = \text{Log}\,\frac{10^3}{9.16}$$

$$= \text{Log}\,10^3 - \text{Log}\,9.16$$

$$3 - .96 = 2.04$$

$$P_H = 2.04$$

In order to show the relation between P_H, C_H, and C_{OH} — the following table has been prepared. This table very clearly shows the balancing of the H and $\overline{OH}$, as one increases the other decreases:

Table Indicating Relationship Between P_H, Hydrogen and Hydroxyl ion Concentrations in Terms of Normality

$$P_H = \text{Log}_{10}\frac{1}{C_H^{+}}$$

	P_H	C_H^{+}	C_{OH}^{-}
ACID	....	1	.000000000000010
	.98	.105	.000000000000096
	1.285	.0519	.000000000000195
	1.995	.0101	.000000000000101
	2.295	.00502	.00000000000200
	2.975	.00106	.000000000090
	3.280	.000525	.000000000019
	4.023	.0000947	.00000000010
	5.004	.00000991	.0000000010
	6.002	.000000996	.000000010
	6.999	.000000100	.00000010
		NEUTRAL	
ALKALINE	7.506	.0000000312	.000000324
	8.030	.00000000933	.00000108
	9.011	.000000000975	.0000104
	10.008	.0000000000981	.000103
	11.022	.00000000000950	.00107
	12.003	.000000000000993	.0102
	13.107	.0000000000000961	.105
	14.032	.00000000000000930	1.09

Report on the Effect of the Petree Process at the Mills and Furnaces as Experienced at Puunene Mill This Past Season*

By Robert E. Hughes

At our last convention, we had with us, Mr. Petree of the Petree & Dorr Company, who explained in detail the working of the Petree Process in connection with, the Dorr Clarifiers, therefore, it will not be necessary to enter into any explanation of the Process in this report.

No doubt, you have all studied, more or less, the Process since then, and followed very closely the working of it at both the Hawaiian Commercial & Sugar Company's factory at Puunene, and the Maui Agricultural Company at Paia.

The Process and apparatus was something entirely new in the Islands, and there was considerable to learn about the working of it. This especially concerned the unskilled labor, who were in the habit of doing their work a certain way, and consequently it took time to train them so that they would fit into the new way.

To us all it was a new experiment, both in the factory and at the mills. In fact, the Process had never been tried anywhere in connection with a shredder, so it must be realized that a perfect run at first was not to be expected with this, any more than was experienced with many other extensive changes made in other years.

The Dorr Clarifiers as installed, consist of one five-compartment and one four-compartment primary tanks, and two four-compartment secondary tanks, with their regular equipment of Dorr Company pumps, overflow tanks, etc.

A one-thousand-gallon cone bottom tank was placed near the clarifiers and on the same floor to receive the mud, thereby providing for some differential between the clarifier discharge of settlings and their application to the blanket of cane at the mills. This was made necessary, owing to the fact that with different varieties of cane the amount of settlings would be greater or less, or they would vary in density to some extent, due to the quality of the juice in process. A poor settling juice requiring faster pumping to maintain the proper mud level in the clarifiers.

The draw-off valve controlling the outlet of this mud tank is located in a convenient position at the mill, it being set to allow an even flow of mud to the cane.

An electric signal consisting of four lights placed in a prominent location at the mills, with corresponding switches in the mud tank, automatically indicates the number of feet of mud contained therein.

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* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

Though endeavoring to maintain an even flow of mud on the cane in quantities equal to the discharge from the clarifiers, it was found at times quite impossible to do so without large quantities of the mud draining away with the juice, thereby being returned in process again through the secondary Dorr supply tank. At this time there appeared to be a great deal of mud returned into process and circulating within the secondary trap. This was thought to be due to the enormous quantity of cush-cush in the mud.

A Peck revolving juice strainer was then installed. This strainer is three feet in diameter by six feet long, and was installed to restrain all the primary juice from the "B" Mill. An improvement in the grinding rate, due to less mud, was noted after this installation, so another strainer was installed to restrain the Mill "A" primary juice before pumping it into the boiling house.

These strainers did wonderful work, removing great quantities of cush-cush, a large percentage of which when washed, would pass through a one hundred-mesh screen, indicating that the cush-cush itself was acting as a filtering medium. In this manner considerable grit and mud were removed as well.

Some mechanical trouble was experienced with the strainers as first installed, but this was soon corrected, so the straining of two-thirds of all the juice from two twelve-roller mills, grinding at 90 to 115 tons of cane an hour, proceeded without any delay caused by these strainers.

Less mud being returned from the clarifiers, owing to the previous removal of cush-cush, allowed our speeding up the mills to take care of the almost daily increasing quantity of cane supplied.

It will be interesting to note here an experiment carried on with this strainer during the last few weeks of the season.

As we desired to know the maximum capacity of the strainer, and to experiment further with the straining of both the primary and secondary juices, two additional paddles were attached to the "B" strainer, and suitable piping installed to carry all the Mill "A" primary juice over to join Mill "B" primary, the combined juices to pass through the "B" strainer. Though the strainer was crowded, it took care of the combined primary juices, amounting to two-thirds of the total juice from both mills while grinding at the rate of 115 tons of cane an hour with dilution of 46.63 per cent. Mill "A" strainer was used to strain all the secondary juice from both mills.

The juice was limed after straining, so that all screenings were returned to the mills minus the lime. This had a somewhat noticeable improved effect on the rollers, especially on the second mill where the mud was applied.

All the juice now being re-strained, which practically removed all the cush-cush, nothing but the mud and settlings were left to be removed with the lime.

Though greatly improved conditions were obtained by the installation of these strainers, there was still a great deal of trouble experienced with the mud on the mills.

Mill settings were the same as those used in previous years, and with which we have obtained some high extractions. Some dry crushing tests to show what has been done in previous years with these same settings will be of interest here:

Mill				
Cr.	61.7	81.8	55.3	82.4
1	20.1		27.1	
2	6.9		6.5	
3	0.8		1.0	
4	2.5		1.0	
Total	92.0		90.9	

These figures are presented to show the extraction obtained by the crushers and first mills before processing, so it is not unreasonable to say that with mill settings and weights practically the same this past season, one would expect the quality of work in the mill to be about the same up to this point.

However, our failure to obtain an average extraction of 98 per cent was due to the excessive amount of rich juice returned to the mills with the mud.

This juice and mud contained a higher percentage of sugar than was contained in the cane entering the second mill, and as there was such a large quantity of juice returned, at times as much as thirty per cent of the cane, it was impossible to effectively apply the proper amount or quality of return maceration that would be required to obtain an extraction of 98 per cent.

When by-passing the third mill juice which normally is used for dilution, we found there would be much less choking, less mechanical conveying and draining away of muddy juice.

This by-passing was not according to process or good milling practice. However, it was only to show the effect that less juice had on the washing out of the mud and choking of the mills.

When operating as a twelve-roller mill, all low density juice must be returned to obtain a fair extraction.

A very noticeable change in the density of the mud took place after a shutdown of say an hour or so, particularly when starting up after the week-end shutdown; the first mud to the mill was always very heavy and more compressed, but it did not remain so.

While operating with this heavy mud, it was plainly indicated, by the darker color of the blanket, that the mud remained mixed with the cane until it reached the furnaces.

The temperature of the mud ranged from 200 to 210 degrees F., this, and the fact that it contained so much juice, caused this choking effect. Forty-seven per cent of the mill breakdown time was due to mill chokes, this in turn caused a slowing down of the grinding rate, for the mill feeder was compelled to feed the mill at a rate which would enable our taking care of the mud.

This choking effect was aggravated by the smoothing of the rollers, the lime counteracting the etching of the rollers by the natural acid contained in the raw juice.

The surface wear of the rollers was practically eliminated, though the very necessary regrooving or sharpening of the grooves at short intervals made up for the reduced wear.

Having established a standard grooving of our own that has taken some years and expense to install, as well as having had excellent results with the

grooves as arranged, we naturally look upon any changing of grooves with caution.

The feed rollers are grooved ¾" pitch, and it became necessary to nick up the surface of these rollers a number of times during the crop.

The liming machines worked well throughout the season. However, when re-straining of juice is practiced, a liming machine equipped with a motor drive will be found to have many advantages over the mill drive.

The Petree Process has, no doubt, contributed to a considerable extent to our great saving of fuel over previous years, by eliminating the mud press and filtration stations, also by the settlings returned to the mill. However, the settlings were greatly reduced by the Peck strainers, removing practically all the cush-cush before clarification, and they should be credited with this saving.

It so happens that other charges made during this same season, caused a saving of much fuel.

Two 300 H. P. boilers formerly equipped with oil burning furnaces and used as boosters, were added to the high pressure steam line as continuous generators, by changing the furnaces to the bagasse burning type.

Another change was that made to the bagasse-burning furnace grates, which permitted the bagasse to burn freely and evenly by preventing the short circuiting of air required for combustion. By this change a higher and more uniform furnace temperature was maintained.

Molasses was burned when the mill operating at a low tonnage supplied an insufficient quantity of bagasse to the furnaces.

An outside load as high as 600 K. W. was carried by the mill electric plant for some months, enough power being sold in this way to give the mill a credit balance.

It is interesting to note that for about twelve days (from December 21st to January 3rd), for a special reason, operations were carried on without Petree Processing. During this interval the mud presses were used and no very noticeable change took place at the boilers; the surplus bagasse pile continued to grow despite the fact that we were grinding at a low tonnage rate, no outside load being carried at the time.

However, there are many other stations throughout the factory where a saving of steam can be accounted for, owing to the perfect clarification by the Dorr Clarifiers, and the removal of cush-cush by the Peck strainers before liming and heating take place. At the heaters, less steam was required owing to the absence of cush-cush in the juice passing through; at the evaporators, less steam was used, due to higher temperature of the clarified juice entering the first cell, and the absence of wash water from the presses. At the vacuum pans less steam, due to better syrup, remelt and molasses. At the centrifugals, power was saved owing to the fact that the much freer drying of both the commercial and low grade sugars permitted our operating this station with only sixty per cent of the centrifugals used in previous years.

The mud had a beneficial effect if any, at the furnaces, and though there was a slight increase in the amount of clinker and ash, it was of a softer composition and easily removed.

A number of improvements in connection with the Process are being looked forward to this season, all of which we expect will help to correct the objectionable features experienced during the past year.

Three Peck strainers will be in use, one to re-strain Mill "A" primary, another Mill "B" primary, the third to re-strain the secondary juices from both mills.

Experiments with a finer screen will be made, commencing with 120 mesh on the primaries and 150 mesh on the secondary strainer.

Below the strainer will be located the primary and secondary juice tanks with their respective pumps. On the top of the primary juice tank is placed the liming machine, which has been converted into a double limer and equipped with motor drive.

The liming of juice from both mills will be done here with one machine.

All the clarifiers are to be fitted with two Dorr Company mud pumps; they can then be operated slowly, and pump without the application of water to the suction side of the pump, which practice had to be resorted to, for the vapors released from the hot mud interfered with the suction. This additional water intensified our troubles at the mills.

The Dorr Company now recommends the lowering of the mud pump to the side of the clarifiers, in place of mounting on the top as at present.

This reduction of suction lift should be a decided improvement, and one which should enable us to obtain a heavier mud.

A Report on Tasseling*

By W. P. Alexander

The subject of the tasseling of sugar cane in its commercial aspect must be divided into two groups, namely:

1. The natural inflorescence of the cane stalk, which has passed through one winter season and which is about to approach the harvesting period.

2. The tasseling of the cane stalk after its first growing season, which is premature.

In the first case the cane is from 16 to 20 months old, and in the second case from 6 to 11 months old.

The phenomena of tasseling of nearly ripe cane has not caused any special cultural operations. On the other hand, the prevention of the tasseling of the "small cane" (mentioned in Group 2) has given much concern on practically all irrigated plantations. On unirrigated plantations also, where Yellow Caledonia is not grown on the lower fields, they have the "tassel problem." The drastic practice of "cutting back" ratoons in July, and also later planting have been a logical means of combating this "evil" of early tasseling.

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* Presented at the Second Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 22, 1923.

In the hope of bringing together data which would review our present knowledge of the flowering of sugar cane, the writer prepared and sent out a questionnaire to members of the Association. While the replies received were few in number, those who did send in complete answers, show that this topic is receiving more attention than it ever has from plantation men.

The writer is indebted to the following for their contributions and interviews in making this report possible: Messrs. H. P. Agee, W. W. Goodale, L. A. Henke, W. P. Naquin, F. A. Paris, J. S. B. Pratt, Jr., Geo. F. Renton, H. D. Sloggett, H. E. Starratt.

All agree that our *exact* sum of information on this annual event in our cane fields is small. We notice that in some seasons tasseling is heavier all over the plantation than in other years; we observe that some fields bloom more thickly, while adjacent fields have but a small number of flowers; we discover that within an individual field some areas are "solid" with arrows, and not over one hundred feet away the cane may be barely sprinkled with tassels.

From our experience and observations we may formulate certain theories and ideas on what we see, only to have them contradicted from year to year. So it sometimes seems that our explanation of nature's workings in regard to tassels becomes mere guess work.

This report, therefore, hopes merely to record the observations and experiences of field men. It should start discussion and open up investigation along this line of research.

Both the normal flowering and premature flowering of the cane warrants study. It is interesting to note that not since 1908, when the late H. P. Baldwin advanced his theories on tasseling and urged more attention to the question, has the subject been under discussion with any concrete data on the *whole* subject. The effect, not only on cane yields but also on sugar content, is so great that a better understanding of this annual function of sugar cannot but be rewarded. If the cane agriculturist can have a directing influence over the tasseling of cane, so that his aims will be accomplished, we have advanced one more step in our cultural methods.

Like everything else connected with the growing of cane in the Islands, conditions vary so greatly, that each district and often individual plantations must determine for themselves the specific factors that enter into their own problem. Generalities cannot be made covering all situations.

Tasseling of Mature Cane

Variety Influence on Tasseling:

Perhaps the most consistent observation every one makes, is that the desire of the cane to tassel is not the same for all varieties. They differ as regards the time of tasseling, quantity of arrows, and ability to keep growing after flowering, by means of lalas. This is a most important and practical point. It means that it is possible to obtain the degree and amount of tasseling which is wanted, by the proper selection of our new seedling canes.

The fact that Yellow Caledonia does not tassel freely, will lala, and not die back if tasseling does occur, has added to its attractiveness under unirrigated con-

ditions. It was abandoned on many irrigated plantations for this same ability to keep growing, because this factor prevented securing high sucrose content.

Professor Henke, of the University of Hawaii, has contributed an interesting table (see Exhibit A) showing the time and quantity of tassels for different varieties.

Yellow Caledonia and Big Ribbon show the least, while Striped Mexican, White and Rose Bamboo, and H 146 head the list. Then comes D 1135 and H 109 and Lahaina in between these extremes.

Badila and Uba are very late tasseling canes. Yellow Caledonia and Tip canes appear in December just after D 1135. H 109 arrows are usually the first ones seen.

Elevation Influence on Tasseling:

There appears to be a direct correlation between elevation and tasseling of the cane. All report practically no tasseling at sea level to a 25-foot elevation. This is particularly true at Ewa, Pioneer and Waialua. There are varying amounts from 25 to 50 feet, but still *relatively* small. Beginning at an elevation of 50 feet, the quantity of cane stalks which tassel increases in direct ratio with the elevation, up to 500 feet elevation. Then there is a falling off until the elevations above 1,000 feet are almost free of tassels. A conspicuous example of this is Hawaiian Agricultural Company at Pahala, Kau, where tassels are known only on a few lower fields.

Figures submitted by Mr. Naquin give 300 to 450 feet as the elevations at which maximum tassels may be secured. From personal observation on Oahu and Maui, the writer believes this to be true also for other conditions beside those at Honokaa.

It then seems established that the kind of cane and the elevation at which it is planted will be two factors in determining how many tassels will be produced. Knowing these facts we are in a position to plant our new and old varieties accordingly.

Mr. Agee doubts if elevation *per se* has an influence on tasseling of cane, but believes that climatic conditions resulting from different elevations do.

Influence of Local Environment:

We would expect local environment of the cane to influence the forces of reproduction of the plant, which is the motive of tasseling.

Length of Day:

Investigations under way by the U. S. Department of Agriculture at Washington, D. C., are proving that it is the amount of sunlight a plant receives that determines the flowering period. In other words, the shortening of the daylight is the chief element in causing many plants to change their directive force from growth to reproduction. There is every reason to believe that this cause applies to sugar cane. The writer has found that the first tassels on Oahu appear at Kahuku, in the fields which after September are in the shadow of the western cliffs late in the afternoon. Mr. Agee points out that cane at the Manoa substation shows a tendency to tassel earlier than at Makiki. The field is located at the foot of a 1,000-foot cliff which is on the western side.

It may be that we can account for the different times at which cane first tassels from year to year, by the varying amount of cloudy Kona weather so common in September and October.

The first flags are sent out in the last week in October or the first week in November according to most reports. The maximum amounts appear just about December 1. Tassels are seldom seen appearing after February 1. A few of the "late varieties" bloom in January.

The lowest elevations have the first arrows, but as Mr. Naquin explains: "While tassels appear at higher elevations later than elsewhere, this is probably due to the fact that the growth up mauka is less than at lower elevations for the same length of time, and even though the tassel is formed in the leaf sheath at the same time, it does not appear, owing to the greater lapse of time which is necessary for a given unit of growth."

Temperature:

Shortening of sunlight is probably assisted by the growth check due to a reduced temperature after August 15, in promoting the tasseling of cane. It has been thought that a sudden drop in the *average* daily temperature, such as a series of cold nights, would result in more and earlier tasseling; and yet others hold that when there is the least daily range in temperature cane tassels most profusely. In 1920, at the Annual Meeting of the H. S. P. A.,* this was discussed pro and con. The late Mr. Baldwin † also advanced his theories in 1908, which held that a high uniform temperature favored tasseling.

Moisture and Plant Food:

While man cannot control the above factors of temperature and sunlight, on irirgated plantations moisture can be regulated, and on all fields artificial plant food can be administered. Later on, it will be shown how the maintaining of the growth desire of the *young cane* plant can be largely influenced by the right application of irrigation water and nitrogen. We are now dealing with the mature cane.

The question of the effect of fertility and moisture on the tasseling of *big cane* appears to be a baffling one to all. Are we right in saying: Give a mature cane perfect growing conditions and you lessen tasseling? As Mr. Naquin says, it is almost impossible to put one's finger on the exact influence that variation of the soil and moitsure content has. In 1922, several fields (19-B and 1-A) at Ewa, that were being ripened, had irrigation suspended, two months previous to November 1st. They produced less than 2 per cent of tassels, while adjacent fields (17-E and 1-F) that had been irrigated steadily, tasseled as heavily as 15 per cent in places. Mr. Naquin states, "In 1917, after a dry spell of ten months, practically no tassels appeared, while in 1918 which was a wet year, the cane tasseled profusely up to 800 feet elevation." To quote Mr. Brecht: "Where there is more water the cane tassels freely."* Mr. Paris observed, "We noticed that cane growing in wet spots was tasseling heavily, where surrounding cane situated on higher land was not tasseling at all. Perhaps Mr. Naquin is

* Proceedings H. S. P. A., 1920, pp. 244-5.

† Proceedings H. S. P. A., 1908, p. 17.

right when he says: "It is an abnormal or a subnormal condition which has a check on tasseling," and Mr. Paris has the same idea: "We may also have a high proportion of tassels in the autumn as a normal end of an exuberant existence."

More experimental evidence is needed, however, to definitely show why, sometimes under very favorable moisture and plant food conditions, cane will tassel, and then again given adverse conditions cane will *not* tassel or vice versa.

Fertilizer does not *always* work on *big cane* to hinder tassels. As the late Mr. Baldwin expressed it years ago, "I have always found that the main factors that affect the tasseling of cane are water, temperature and air." He laid stress on the prevention of the circulation of air in heavily fertilized cane as a cause for small number of tassels.

The general observation is that all fields tassel heavily on the outside. Mr. Paris expresses his theory of this as due to the wind, giving two reasons: "The quick evaporation of the moisture in the soil causing irregular growth of the plant, and the disturbing effect of the wind on the root system. The stalks are pushed over by the wind, the roots broken or the contact between them and the soil, becomes imperfect, thus preventing a good circulation from the roots to the upper part of the plant, causing insufficient nourishment."

The writer is inclined to guess that the tassels along the edge are caused by a *slight* checking of growth following a quicker drying out of the soil in this portion of the field. Also the changes in temperature are greater on the exposed side of the field.

Such tasseling along the edge of the field and ditches is deceiving as to the true proportions of stalks within the field which are actually flowering.

The writer had noticed that tassels were thicker along the watercourses, but was surprised to find that counts in 1923 showed that the ten feet of cane on each side produced over half (51.09 per cent) of the total flowers in the field. These counts represented 62 lines taken from *all* the fields.

The "Baldwin Theory" of the circulation of air may account for the amount of tassels on the edge of the field and near the watercourses. The writer also believes that the large amount of water, with the successive abnormal wetting and drying out which this cane is subject to, may have some effect on this cane adjacent to watercourses.

Influence of Plant and Ratoon Cane:

At Ewa, mature plant cane does not tassel as heavily as ratoons. The following average figures based upon counts verify observations:

	1922	1923
Plant Cane (5 fields)	4.06%	5.22%
Ratoon Cane (5 fields)	9.27%	9.13%

Mr. Paris believes that on Oahu, plant and ratoon cane tassel in about the same proportion when conditions are favorable for it. Mr. Naquin has made counts of tassels in 30 fields of plant, first, second and third ratoons and concludes, "There is but a slight difference in the amount of tassels sent out by the

* Proceedings H. S. P. A., p. 245.

plant and ratoon cane, and on account of the wide variation in soil conditions, it is almost impossible to arrive at accurate figures."

Age of Cane:

The age of mature cane influences the percentages of tassels to some extent, but may be outweighed by other factors, such as elevation. At Honokaa, 15 months cane in 8 fields at different elevations averaged 15.25 per cent, while 10 months old cane 12.25 per cent, and 5 months old cane gave no tassels.

Effect of Tasseling on Mature Cane:

Before one can determine the effect that tassels have on mature cane, one must know how many stalks have arrowed.

Anyone making counts will be surprised to find how misleading observations are. A field which presents a solid purple hue and in which it appears that every stalk must have tasseled, will be found to have but 50 to 60 out of every 100 with a flower, more often the percentage will be less. Counts have been made at Ewa for three years, of the percentage of tassels in each field, and the results below give summarized figures of that portion of the plantation having specific amounts of tassels:

	Per Cent of Total Area	
Fields With	1922	1923
No tassels	12.60%	4.13%
Trace	18.66%	26.89%
Only tassels along edge	22.17%	2.82%
Under 5%	12.52%	30.69%
5 to 10%	7.45%	15.74%
10 to 15%	5.67%	16.16%
15 to 20%	2.95%	0.00
20 to 30%	8.19%	2.28%
30 to 50%	4.65%	1.29%
Over 50%	5.14%	0.00

Averaging figures from all fields where counts were made at Ewa we secure:

1922 crop	8.06 per cent tassels
1923 crop	8.30 per cent tassels

The highest percentage reported by Mr. Naquin is 44 per cent. His average figure would be 19.21 per cent.

Cane stalks which have *recently* tasseled have a higher sugar content than those that are continuing to grow. These tests are average figures of a good number of samples from H 109 at Ewa Plantation:

	Brix	Pol.	Purity	Q.R.
Tasseled Stalks (no lalas yet)	18.24	16.61	91.06	7.88
No tassels (no lalas yet)	17.72	15.58	87.92	8.60

However, after several months have elapsed the reverse seems to be true for unirrigated conditions. The difference in tests at Honokaa were small but in favor of non-tasseled D 1135 cane.

	Brix	Pol.	Purity	Q.R.
No tasseling (3 months after)	18.43	16.92	91.81	7.69
Tasseled Stalks	18.26	16.62	91.02	7.87
No tasseling (6 months after	17.56	15.96	90.89	8.21
Tasseled Stalks	17.44	15.61	89.51	8.48

When the cane tassels three things may happen: (1) the stalk will send out lalas or side shoots from the topmost eyes; (2) all growth of the stalk will cease and the cane will eventually die back; (3) new growth will be concentrated in sending out suckers from the original stool. So it would seem while there is a storage of sugar in the tasseled stalk to begin with, this condition is temporary. The juice of the lalas and suckers are poorer, and any such growth draws upon the accumulated sugar in the main stalk. When the cane dies back without lalas, deterioration of the sucrose sets in.

Granted that there may be a slight increase in sugar content when development of the cane is arrested by tasseling, indications are that this gain is not permanent and may be more than offset by the tonnage of cane lost in the interrupted growth.

Therefore, unless the cane is to be harvested within several months after tasseling, the flowering of the stalks is not beneficial. This is especially true in dry regions. Mr. Naquin explains the reason: "As a great deal of growth in this district is made in the winter months, when water is not a limiting factor, we feel tasseling is not desirable. We have found that under certain conditions cane does not lala, consequently it dies out and there is a double loss. Mr. Paris adds this idea: "After heavy tasseling, the suckers are likely to be numerous, especially on good soil. They spoil the juice."

Tasseling of Immature Cane

As has been stated before, it is the tasseling of half-grown cane following the first season, which is the "bugbear" of many plantation men. To prevent this, the practice of "cutting back" in July has been in vogue.

Under what conditions does cane (plant or ratoon) tassel after the first season? What proportion of the stalks tassel? Do the canes that tassel produce new side stalks or lalas? How does irrigation affect the tasseling of this cane? Will nitrogen fertilizer influence the tasseling of the cane? Is cutting back necessary? Is late planting necessary?

The above questions are involved one with another and cannot be answered definitely for all conditions.

What has been stated in regard to the influence of varieties, elevation and local environment, etc., on mature cane applies in a general way to young cane. The age of the crop, however, plays a more important role in this immature cane.

Ratoons: Cane harvested in January will arrow the following November, unless grown on the very lowest or highest elevations and from the lesser tasseling varieties such as Yellow Caledonia or Badila. This applies in a lesser extent to February and March harvest. April cut cane will or will not tassel, depending on conditions. Cane cut in May probably will not arrow. June cane is almost safe, though there are exceptions.

Plant: Cane ordinarily can be planted after May 1 without fear of much tasseling. Opinion and experience from fields planted earlier differ greatly. At Ewa, plant cane of H 109 will not produce many tassels, although started in February.

The above summarizes what many cannot agree upon, because the tasseling will vary so much with seasons and local conditions.

The proportion of stalks tasseling in cane, harvested or planted in different months, has not been worked out experimentally for all conditions. Actual counts will show that except for exposed fields and those on higher elevations (above 150 feet) the numbers will be negligible, i. e., less than 8 per cent. For those fields cut during and before March, the amount will depend largely upon treatment, but should not be over 20 per cent.

Most varieties that are planted below 1,000 feet elevation will bring forth lalas, if there is not extreme cold and dampness.

Fertilizer, in quick acting nitrogeneous form, has a decided effect on reducing and often preventing tasseling of immature cane, provided it is applied at the right time, and followed with *sufficient* irrigation. We have seen this demonstrated at Ewa, not only in experiments but also in field practice.

Cane irrigated *regularly* (not over 20-day intervals) from August through November stands a much better chance of not tasseling. Any check to the growth of cane during this period, either due to a lack of plant food or not enough soil moisture, will be liable to change the "growing desire" of the plant to one of reproduction, i. e., tasseling. The shorter days and colder weather are pulling one way, and to counteract their influence the growing environment must be made as favorable as possible.

Whether it is necessary to "cut back" all cane started before June 15, either in plant or ratoon, is a question to be decided by each plantation, irrespective of what others are doing. It was hoped to present the views in detail of those who favor cutting back and practice same. The answer to the writer's question, "Does cutting back pay?", was merely answered in the affirmative.

The wish of all field men who are responsible for maximum yields, to play safe, is justified, provided the practice of cutting back is not merely one of rule of thumb, but is backed with experimental evidence.

The matter has been decided for the Ewa Plantation Company by Manager George F. Renton, Jr., as follows:

All cane to be ratooned, cut previous to March 31, will be a short ratoon, so while tassels are not wanted, their influence if they do appear, will not be injurious. There is no cutting back of any field. Fields at the higher elevation are taken off later. Fields harvested in April and May will be given special treatment to minimize the opportunity for tassels to appear in November. The above policy is based upon experience with H 109 in field practice plus the results from five experiments conducted under different conditions on the plantation. These tests showed that "cutting back" brings no benefit to the growing crop. In fact, four out of the five experiments registered a distinct gain for non-cut-back plots, viz:

Field A. S. Co. No. 2	1.99	tons sugar per acre
10-A	1.83	" " " "
19-B	1.12	" " " "
1-C	.77	" " " "
Average	1.43	

The fifth experiment in Field 1-A gave neither a loss nor a gain for not cutting back.

By not cutting back, the labor was saved in two ways: The men used in performing this operation were eliminated; fewer men were required in hoeing, as the cane closed in quickly and shaded out the weeds.

In 1920, Mr. Allen, then at Kilauea, found that a field in which there were 48 per cent of tassels after the first season continued to grow so that the stalks with lalas weighed more than those canes which had not arrowed.* Calculation showed that the tasseled stalks would produce 4.0 tons of cane per acre or .35 tons of sugar per acre more than the untasseled canes.

Here, then, is some proof of the contention held by many, including the writer, that where a variety will lala, a small percentage of tassel will not damage the ultimate yield. The growth of lalas, while probably poorer under most conditions than continuous growth, will, nevertheless, offset the great loss in growing time which cutting back causes.

Mr. Naquin, of Honokaa, states that: "We do not feel that under any conditions cutting back of young cane is justifiable." Mr. Agee tells how at Oahu Sugar Company a field of Lahaina cane with 16 per cent tassels when small showed a gain for no cutting back. Mr. Hind,† of Hawi, has called attention to the fact that cutting back with some varieties and under certain conditions brings about too rank a growth and consequently smaller sticks, and in many instances it is more advisable to risk a small per cent of tasseling rather than resort to cutting back. Mr. Paris goes into great detail and is very emphatic about losses due to cutting-back. His remarks proving his contentions with hypothetical figures are found in his report in its appendix.

Referring to the Annual Proceedings of 1920, H. S. P. A., it is evident that cutting back is on the decline; for example, in 1916 the Hawaiian Commercial and Sugar Company cut back 4,600 acres, while in 1920 only 600 acres were cut.

The tasseling season is at hand again, and when the members of the Association return to their respective plantations it will pay them to observe for themselves, the causes and effects of the tasseling. Then, perhaps, at our next annual meeting new data may be placed before the Association.

Summary

1. Tasseling of cane is not the same for all varieties. Cane breeders need to watch tasseling.

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* Hawaiian Planters' Record, Vol. XXVI, p. 90.

† Report of Committee on Cultivation, Fertilization and Irrigation of Irrigated Plantation, 1920, p. 13.

2. The shortening of the amount of sunlight which cane receives upsets the equilibrium of a plant so that it wishes to reproduce. Tassels are the result in cane.

3. Tasseling of cane differs for different elevations.

4. There are differences of opinion as to just what effect climate, as reflected in temperature, has on tasseling.

5. Moisture and soil variations influence the amount of tassels. Normal growth conditions favor tasseling.

6. There is evidence that mild air currents or more violent winds affect cane so that it produces tassels.

7. A greater yield of cane can be secured if mature cane does not tassel. The winter growth is desirable under most conditions.

8. What little data has been secured indicate that if, at least under unirrigated conditions, tasseled cane is not harvested fairly soon after flowering, poorer juices will result than if the cane had not tasseled.

9. A certain amount of immature ratoon cane will tassel if harvested previous to May 1. Cane planted in January to May may also tassel during the first season. Under some conditions this can be minimized or prevented entirely by specific treatment.

10. Cutting back in July to eliminate tasseling is too drastic treatment. Experimental data is necessary to determine if this practice can be avoided.

11. Proper application of fertilizer and irrigation is the remedy offered to reduce the percentage of tasseling in immature cane.

12. More experimental data is needed to show what percentages of immature cane can tassel without a harmful effect. Indications are that, provided a cane will lala, damage is overestimated.

13. Cutting-back is not being practiced on such a large scale as formerly.

APPENDIX

QUESTIONNAIRE ON TASSELING

I. Questions regarding the tasseling of cane that is almost mature.

(a) **Time of Tasseling.**

1. When do tassels first appear?
2. When may tassels last appear?
3. During this period, when do the majority of tassels appear?
4. What effect has climatic conditions on time of tasseling?
5. What effect has elevation on time of tasseling?
6. Do different varieties tassel at different times?

(b) **Quantity of Tassels.**

7. What proportion of cane stalks send out tassels under the following varying conditions? (Give actual counts if you have made them.) Variety; Plant cane; Ratoon cane; Types of soil; Elevation; Poor and good drainage; Protection from wind; Exposure to wind.
8. Are varying climatic conditions from year to year responsible for different amounts of tassels?

(c) **Effect of Tasseling.**

9. In your opinion, how is (1) the cane yield and (2) the sucrose content influenced when:
   a. Tasseling is less than 10 per cent;
   b. Tasseling is from 10 to 25 per cent;
   c. Tasseling is from 25 to 50 per cent;
   d. Tasseling is over 50 per cent.
10. Do you favor tasseling of cane that is to be harvested within six months from the time of tasseling?

(d) **Cause of Tasseling.**

11. What do you consider the cause of tasseling?
12. Can tasseling be controlled by:
    a. Fertilization?
    b. Irrigation?

II. Questions regarding the tasseling of cane less than one year old.

13. Under what conditions will cane cut in the following months tassel during the next winter: January? February? March? April? May? June?
14. Do you consider it necessary to cut back cane started in the above months? If so, when would you cut back?
15. Will the cane require special treatment if no cutting back is practiced?
16. Assuming that this immature cane does tassel (a) less than 10 per cent; (b) 10 to 25 per cent; (c) 25 to 50 per cent; (d) over 50 per cent; what effect will this have on the ultimate yield?

(CONTRIBUTION FROM W. P. NAQUIN, OF HONOKAA.)

The natural function of any plant is to flower and reproduce itself by seed, and accordingly the tasseling of sugar cane is a natural phenomenon. Sugar cane belongs to that class of plants which produces flowers in the winter months, the flowers being induced by the shortening of daylight hours. Since cane at higher elevations tassels less frequently than that at lower elevations we believe that low temperature will check the tasseling of cane.

The age of the cane is also a factor in the number of tassels which will be produced, as is clearly shown in the following table:

EFFECT OF AGE AND ELEVATION ON THE TASSELING OF SUGAR CANE

Variety D 1135

Elevation	Per cent Tassels		
Feet	15 Months	10 Months	5 Months
300	20	22	0
350	24	13	0
400	26	10	0
450	25	21	0
500	10	11	0
550	4	15	0
600	10	4	0
650	3	2	0
Average	15.25	12.25	

In the Hamakua District tassels generally appear from the 10th of October to the 1st of February. The majority appear from November 1st to 30th—the prevailing weather having quite an affect in determining the amount of tassels which occur from year to year. In 1917, after a dry spell of ten months, practically no tassels appeared, while in 1918, which was a wet year, the cane tasseled profusely up to the 800 feet elevation. A greater

number of tassels appeared at the lower elevation, in fact at the 1,800 feet level there were no tassels. When they do appear at the higher elevations they appear relatively later than elsewhere. This, however, is probably due to the fact that the cane growth up mauka is less than at lower elevations for the same length of time, and even though the tassel is formed in the leaf sheath at the same time it does not appear, owing to the greater lapse of time which is necessary for a given unit of growth.

There is also a difference in time of tasseling in the different varieties. In certain years in this district Uba and Badila tassel late, from the 1st of January through to February, while H 109 and D 1135 tassel before the end of the year.

As far as we can learn there is but slight difference in the amount of tassels sent out by plant and ratoon cane, and on account of the wide variation in soil conditions it is almost impossible to arrive at an accurate figure on this. We have, however, prepared a table showing such variations, which is given herewith:

EFFECT OF RATOONING ON TASSELING OF CANE.

Variety D 1135.

		Per cent Tassels		
Elevation Feet	Plant	1st Ratoon	2nd Ratoon	3rd Ratoon
300	25%	14%	53%	0%
450	11	23	5	44
450	26	20	0	24
450	44	27	28	32
450	0	21	0	24
500	15	23	13	16
550	34	34	8	19
550	0	13	13	34
600	6	10	13	37
Total	161	185	133	230
Average	23%	20.5%	19%	28.7%

The variation and moisture content of the soil has also a great deal to do with the amount of tassels, but it is almost impossible to put one's finger on the exact influence which it has. Fields are often spotted with tassels, some places having practically none, while in others as much as 50 per cent of the cane is tasseled. Our observation shows that exposed hillsides are more prone to tassel than protected hollows. There are also more tassels along the level ditches than farther away from same.

The effect of tasseling on the quality of the cane has been studied for the past several years, and we have prepared a table showing the quality ratio three and six months after tasseling. This shows a higher quality of cane in the non-tasseled than in the tasseled cane.

EFFECT OF TASSELING ON THE QUALITY OF CANE

Variety D 1135.

Three Months After Tasseling.

	Tasseled Cane			Non-Tasseled Cane		
	Brix	Sucrose	Purity	Brix	Sucrose	Purity
	18.51	16.63	89.84	19.47	17.83	91.58
	17.51	15.88	90.69	18.04	16.40	90.91
	19.23	17.56	91.32	19.35	18.13	93.70
	18.44	17.03	92.35	18.91	17.63	93.23
	18.14	16.54	91.18	19.11	18.10	94.71
	18.54	16.98	91.59	17.95	16.27	90.69
	17.85	16.18	90.64	15.94	13.74	86.12
	17.85	16.18	90.64	18.64	17.27	92.63
Total	146.07	132.98	728.25	147.41	135.37	733.57
Average	18.26	16.62	91.02	18.43	16.92	91.81

Six Months After Tasseling.

	16.53	14.45	87.4	17.47	15.56	89.1
	16.54	14.04	84.	16.01	14.05	87.7
	17.25	15.51	89.91	17.91	16.26	90.79
	17.73	16.18	91.25	17.68	16.19	91.57
	18.77	17.05	91.84	18.47	16.82	91.07
	18.86	17.61	93.37	18.55	16.94	91.32
	16.45	14.47	87.96	16.85	15.24	90.45
Total	122.13	109.31	625.73	122.94	111.06	632.
Average	17.45	15.62	89.50	17.56	15.96	90.34

Since tasseling halts the growth of the cane there is no doubt that the amount of cane produced per acre is less with tassels than without. As a great deal of the growth in this district is made in the winter months, when water is not a limiting factor, we feel that tasseling is not desirable. We have found that under certain conditions cane does not lala, consequently it dies out and there is a double loss. This condition occurs when the tasseling season is followed by a drop in temperature below the critical point at which cane will lala.

Tasseling can be, to a certain extent, controlled by intensive cultivation. A strong growing plant generally tassels less than one which is growing normally. A heavy dressing of nitrate of soda, applied just previous to the formation of tassels in the leaf sheath, which is around the last of August, followed by all the water required, will practically prevent tasseling.

We also feel that the opposite is true to a certain extent. From our experience in 1917 when the dry spell was of such intensity that the cane was practically dormant from March until the first of November, when good rains fell and things started growing, very few tassels appeared, as previously mentioned. In other words, it is an abnormal or a subnormal condition which has a check on tasseling.

Cane which is cut in January, February, March and April receives a special treatment to prevent excessive tasseling. In the case of young cane, it is preferable to force the growth ahead rather than to check same. Cane cut after the end of May and June requires no special care to prevent tasseling.

We do not feel that under any conditions cutting back of young cane is justifiable. Even though 50 per cent of the cane was to tassel and die out the remaining stand is more than sufficient to produce a normal crop. On an average we have in our cane fields about twice as much cane at 8 to 10 months as will be harvested, and whether we weed it out by means of tassels or by the survival of the fittest the ultimate results, we believe, will be about the same.

We are indebted to Mr. E. E. Naquin for the tables supplied above.

(CONTRIBUTION FROM F. A. PARIS, H. S. P. A. SUBSTATION, WAIPIO.)

I. (a) 1. The first tassels were observed at Waipio on November 4, 1922. We noticed some on Honolulu Plantation on the 30th of October.

2. The last tassels appeared on December 20, 1922, but these never developed completely.

3. The heaviest tasseling was noticed during November.

4. Cold weather seems to cause an early tasseling. In Peru, for example, tassels are observed during cold years only.

5. Lower fields begin to tassel early.

6. H 456 and H 109 tasseled here earlier than D 1135, Badila came last and tasseled very slightly compared to other varieties, in fact, last year we could not find any Badila tassels among cane of about one acre. Our new seedlings behave very differently with regard to tasseling, some tassel very freely and some not at all, even when the cane is nearly mature.

(b) 7. Plant cane and ratoon cane on Oahu tassel in about the same proportion when conditions are favorable for it. Both have a tendency to tassel more at the higher elevations. On the Kohala coast where the lower fields suffer from drought more than the upper fields, the situation is reversed. In poorly drained soils the tasseling is very heavy. We noticed that cane growing in wet spots was tasseling heavily, while the surrounding cane situated on higher land was not tasseling at all. Cane exposed to wind tassels more for two reasons, the quick evaporation of the moisture in the soil causing irregular growth of the plant, and the disturbing effect of the wind on the root system: the stalks are pushed over by the wind, the roots broken or the contact between them and the soil becomes imperfect, thus preventing a good circulation from the roots to the upper part of the plant and insufficient nourishment. On the Kohala coast where the wind is blowing hard for months at a time the tasseling on the most exposed spots was very heavy. One of the reasons for the tasseling being heavier on the edges of our fields here, is the disturbing effect of the wind.

8. Climatic conditions are partly responsible for different amounts of tasseling. A cold or very dry year will increase the amount of tassels, but a very favorable year for growth may bring a well cultivated cane field quicker to full development and in that case we may have also a high proportion of tassels in the autumn, as a normal end of an exuberant existence.

(c) 9. If the cane is cut soon after tasseling, especially after heavy tasseling, the sucrose content in that cane will be higher than in cane with no tassels or very few, as tasseling puts a stop to further development of the stalks, creating early maturing. But if that cane is left for a few months in the field and the rainfall is heavy the cane will lala, and if it is recumbent, or if the stand is thin, many suckers will grow and reduce greatly the sucrose content. Therefore the earlier we cut the cane after tasseling the better, and the smaller the losses compared to cane which has not tasseled.

Twenty-five per cent tasseling can cause a loss in sugar of about a hundred and twenty-five pounds.

Fifty per cent tasseling, two hundred and fifty pounds.

These losses are calculated on the basis of 0.5 ton of sugar per acre per month and taking a loss of one month's growth due to tasseling, the cane being 16 to 17 months old.

10. I do not see any reason for favoring tasseling even in cane within 6 months of harvesting, the lalas likely to grow after the cane has tasseled make the cutting more difficult, their juice is of inferior quality, a good many are broken off and are left in the field at the time of harvesting. After a heavy tasseling the suckers are likely to be numerous, especially on good soil, they spoil the juice very much.

(d) 11. Tasseling, as we mentioned before, is the normal end of a very normal development of a plant when it takes place with heavy cane from 18 months to 2 years old, but when it comes earlier it is always the result of some disturbance of the vegetation caused by climatic conditions, or imperfect cultivation or diseases and pests. The more perfect the conditions the less tasseling.

12. Fertilization is one of the important factors we possess to control vegetation in our fields, especially when fertilizers are used in a soluble, concentrated form. We can counteract the bad effect of unfavorable climatic conditions, correct insufficient fertility in our soils, create uniform conditions. By the intelligent use of fertilizer tasseling can be reduced to a negligible proportion. We noticed often a weakening of the vegetation in cane from a year to 14 months old; the quantity of fertilizer

applied was not sufficient to carry the crop through in one uniform swing; the cane under this condition will tassel heavily.

At Waipio the tasseling in our 15 to 17 months old cane, plant or ratoon, is never above 15 per cent, and even less in our best fields. This year we have 5 to 7 per cent tassels in plant cane and up to 11 per cent in third ratoons. We expect yields from 12 to 14 tons of sugar per acre and more. The fertilization varied from 300 to 350 pounds of nitrogen per acre and in same cases sixty pounds of phosphoric acid, both applied during the first year.

(b) Irrigation influences the tasseling in about the same proportion as fertilization. The proportion of moisture in the soil should be kept near the ideal for the maximum growth of the cane; under our conditions that proportion amounts to between twenty-five and twenty-six per cent, and to keep it up during the summer months we have to irrigate about every seventeen days. Light irrigation from one and one-half to two-acre inches at a time, given every two weeks, seems to be better than heavy irrigations from four and a half- to six-acre inches given every three weeks. We estimate that the gain in favor of a light irrigation amounts to about a ton of sugar per acre, and the quantity of water used will be less. The cane requires at least a hundred and thirty-acre inches to get up to maturity. During the months of August and September the irrigation ought to be rather more frequent, as a shortage of moisture during that period would cause a heavier tasseling.

We have at Waipio a few plots which have not been fertilized for the last ten years. They were planted in 1921 with H 109 and they will yield about twenty-five tons of cane per acre against a hundred to a hundred and ten tons from the adjacent fertilized plots. The irrigation was uniform for the fertilized and unfertilized sections. The tasseling in the unfertilized cane amounts to about one hundred per cent against about fifteen in the fertilized cane.

It shows that water and fertilizer must be combined to obtain maximum results and with regard to tasseling, adequate fertilization is probably even more important.

II. 13. January is a very bad month for starting a crop of cane. It is generally a wet, cold month, preventing any cultivation. Harvesting during that month should take place in fields which are going to be plowed up. From February to June the conditions which will cause tasseling are the same: Exceptional and unfavorable climatic conditions like cold or heavy winds, excess of moisture, insufficient fertilization and irrigation. The poorer the soil and the more unfavorable the situation of the field the more important will these conditions be. A late hilling up and an excessive hilling up will also disturb the root system to such an extent that the cane will suffer an irreparable check at the beginning of life which will cause tasseling. Suckers left over from the previous crop will tassel. An imperfect irrigation system is often responsible for a very irregular stand of cane and heavy tasseling in young cane.

Tassels are more numerous along ditches and on the periphery of a field, especially in ratoon fields. We put it down to stools being high above the irrigation furrow or in an unfavorable situation in regard to irrigation. On the outside fast growing canes are likely to fall over, the roots being disturbed and the circulation in the stalk hindered; naturally any of these conditions would check the growth and provoke tasseling. Outside stools stool more, they go on stooling for a longer period, gradually due to the fact that some of the early shoots are weakened and they tassel. In ratoon fields the trash is pulled up on the periphery of the field when the trash is burned after harvesting, the out-

side lines have been stripped by the irrigation gang and there the trash is scarce, so that many of the young suckers are not killed by the fire and they come up in the next crop and tassel early.

14. Under our actual conditions here and the amount of knowledge we possess, early tasseling can be reduced to such small proportions that from a business point of view, cutting back should not take place. We believe that in the past the importance of tasseling as a yield reducing factor was greatly exaggerated. We do not think that counts were made in the field to determine the exact proportion of tassels. A twenty-five per cent tasseling field will look, from a distance, like having one hundred per cent tassels, and as often put down as such before, according to old hands.

    At Waipio during 1921, our short ratoons started from March to May did not tassel at all nor did the cane planted in March, April and May. On the plantations, tasseling was very slight, too, where the cane was not cut back. This year we counted, in a field started in March, an average of 24,720 sticks per acre with 115 tassels per acre, giving 0.46 per cent. In cane cut in April and May we have an average of 26,880 sticks per acre at one place and 30,750 sticks per acre at another place with 0.42 per cent and 0.374 per cent tassels per acre respectively, the number of tassels was from 115 to 120 per acre in both cases. In cane planted in March, 1922, we have practically no tassels. This field consists of eleven acres of pali land of poor quality and the soil in many places is very shallow. The heaviest tasseling of short ratoon cane we counted on a plantation this year was 23 per cent. The cane was fertilized rather late for the first time, and cut very early in the year. In another case, noted on one of the plantations, the cane which was not cut back in a field, the remainder of which was cut back on the 10th of July, only tasseled to the extent of 0.4 to 0.5 per cent. (About 120 tassels per acre in cane running from 24,000 to 25,000 sticks per acre.) The field was irrigated fairly regularly every three weeks after harvesting, which took place in April. The fertilizer was applied late, July (1,000 pounds high grade per acre). The stalks coming up after cutting back are very small on account of an excessive stooling, the future of that cane is less promising than the not cut back. The tonnage now is very much superior in the last mentioned.

15. In the case of not cutting back, care is required so as to prevent any check in the growth of the cane from the time of starting up to the time the tassels are likely to be formed, especially during the months of July and August, the young cane must be in good growing condition, well supplied with fertilizer and water. If the crop is started early in the year two doses of fertilizer should be applied up to August, and in the case of short ratoons the full dose should be in by the end of September.

    The earlier a field is irrigated and fertilized after harvesting the better it is, not only to gain time during the best growing period of the year but also to provoke an early stooling and a quick shading of the soil, preventing in that way the growth of weeds and conserving tilth in the soil.

    At Waipio we obtained very good results through applying fifty pounds of nitrogen in plant cane about six weeks after planting, in ratoons immediately after the first irrigation. Six weeks later the second dose of one hundred pounds of nitrogen is applied, followed by a third dose of one hundred to one hundred and thirty pounds of nitrogen when the cane is from five to six months old. In long ratoons and long plant the third dose comes early in the second year and varies in quantity according to the stand of the cane.

Complete fertilizer against nitrogen only had no restraining influence on tasseling. In ratoon fields the breaking up of the ridges in between the cane rows and a slight hilling up may favor the growth of the cane and reduce slightly the number of tassels. Paper mulch did not influence tasseling in either way.

There is nothing definite about the time fertilizer should be applied. It is up to the man to watch the cane and feed it according to the needs so as to keep the vegetation going at full speed, as long as the climatic conditions permit it. An early start and a good start leaves scope for improvement, and increase of yield, but any check due to late fertilization is irreparable, the more so when it happens a few months after the crop was started. We should certainly rather neglect canes getting near the end of their life or a field not having been started, than young cane a few months old and in good shape. The term "feeding the baby" applies to cane as well as it applies to animals, and the art of feeding plants is as delicate as the feeding of valuable stock. Both require a thorough knowledge and a keen observation. We have the feeling that as far as man is concerned a crop of cane is made during the first seven months and it is only through intensive application of our best cultivation methods during that period that success is obtained.

16. To calculate the loss through young cane tasseling during the first year, we base our calculations on the production of sugar of 0.5 ton of sugar per acre per month, an average which ought to be considered normal under good conditions in our district. Taking one of the worst cases against not cutting back, say 50 per cent tassels, in cane cut at the beginning of February, we get the following figures:

Losses per Acre.

		Cut back July 10	Not cut back
From February to July....	Irrigation Wages	$15.00	$15.00
	Water	28.00	28.00
	Cultivation	3.75	3.75
	Cutting Back	2.00	......
	Rent, etc.	5.00	5.00
		$53.75	$51.75
	Sugar loss:		
	5 months at 0.5: 2.5 tons at $110	$275.00	......
	9 months at 0.25 ton: 2.25 tons at	......	$247.50
	Balance in favor (per acre) not cut back...........	......	29.50
		$328.75	$328.75

Taking cane cut in April and tasseling up to 25 per cent in November the loss, in sugar per acre would be, if the cane was cut in August of the following year, 1.12 tons. If cut back in July we should lose three months at 0.5 ton of sugar per acre per month, or a total of 1.5 tons sugar, plus expenses of irrigation, etc., up to the time of cutting back.

In each case cutting back is proved to be a loss, and that without taking into consideration the better results obtained with a crop started early. Cutting back would also render a short cropping impossible, an opportunity which is closely connected with improved methods of cul-

tivation and the development of fast growing and early maturing strains of cane. The possibilities which shorter cropping periods offer to the industry are important, they have already been mentioned by the Station.

Comparing cutting back with not cutting back during a series of three crops we get the following figures:

Not Cut Back	Cut Back
Field started February, 1922	Same field started July 10, 1922
cut August, 1923	cut March, 1924
cut April, 1925	started July, 1924
cut August, 1926	cut April, 1926
	started July, 1926

In summing up the yields through the years we come to a total of 26.0 tons of sugar per acre for three crops with the not cut back system against 20.0 tons per acre for two crops when cutting back, a difference of 6.0 tons in favor of the former system. We have to add to that the cheaper cost of production connected with the non-cutting back system, a gain which would more than pay for the higher harvesting expenses. We are here very conservative in the estimation of yields for the short crops.

With regard to the importance of early fertilization we would like to mention here the rapidity with which young cane in perfect growing condition will absorb high doses of nitrogen, and the increase of growth obtained when that element is supplied in large quantities during the first growing season.

We noticed repeatedly, that the cane about three months old which had already been fertilized with fifty pounds of nitrogen and was growing fast, would absorb within five or six weeks a hundred pounds of nitrogen, at least past that period the color of the cane was slightly fading, and the growth beginning to slacken. It is only when we get to about two hundred or two hundred and fifty pounds of nitrogen per acre that the effect seems to last longer.

In short ratoons sixteen and one-half months old we measured canes 21′ 6″ long, which means a weekly average growth of 3.58″ up to the day of harvesting, the cane having been seventy days without irrigation previous to harvesting. The average weekly growth of several other stalks measured in the same field was 3″ and above. The stalks measured were all primaries, but taking an average of four stalks per stool and 24,000 stalks to the acre, sixty weeks old, a 3″ growth a week would give us yields of one hundred and forty-four tons of cane per acre or .960 tons of sugar per acre per month. These results show the possibilities for cultivation of creating such ideal conditions that these high yields will be realized over a large acreage.

Grouping of the best fields in a number 1 zone or section for intensive treatment, permanent plant tests, shorter cropping, weekly growth measurements and moisture determinations in the soil, must come in for such fine work. In making the field work intensive and accurate and so productive, how much more interesting, fascinating it becomes from an agricultural, from a business point of view. It will be a great stimulus for a man to have more and more the feeling that the crop is his.

(CONTRIBUTION FROM H. P. AGEE.)

Without attempting to take data last season, and answer your questions in detail, I give as follows the general impressions which I hold on the subject of cane tasseling:

Time of Tasseling: Climatic conditions no doubt have a pronounced effect on tasseling. In Hawaii, tassels appear in November; in Cuba, in January. I doubt if elevation *per se* has influence on tasseling, but climatic conditions resulting from different elevations undoubtedly do. This is shown very clearly at Pioneer Mill Company, where the low areas do not tassel, while those at 50 to 100 feet elevation do tassel. The time of tasseling of different varieties is somewhat different. The Japanese cane (Uba) and Badila tassel later than most varieties. Most of our varieties, however, tassel at approximately the same time.

Quantity of Tassels: Tasseling is apt to be heavier in ratoon cane than in plant cane. Anything affecting the tendency of the cane to mature influences the amount of tassels. This is illustrated very clearly by the practice of cutting back. Canes starting in July are not big enough to mature tassels. Canes started a month or two earlier have a tendency to tassel. We may offset this tendency by forced growth from irrigation and fertilization. If we irrigated and fertilized heavily during the early part of the summer and then allowed a check to come about the month of September, tasseling would be expected. Any check during the growth of cane during August or September tends to increase the number of tassels provided the cane is big enough to set them.

The formation of tassels, that is the maturing of the cane plant, in the fall or winter, is due, in part, to cooler temperatures and to decreased sunlight. Cane in upper Manoa Valley shows a tendency to tassel earlier than here at Makiki. I think this is due to the fact that the sunlight in the valley is cut off by the surrounding mountains. 1922 was a year with a large amount of tasseling on Oahu. I attribute this, at least in part, to the dry summer and the difficulty in keeping cane well irrigated.

Effect of Tasseling: An experiment with Lahaina cane at Oahu Sugar Company several years ago showed benefit from not cutting back when there was 16 per cent of tassels. As to whether benefit or loss will result from a given per cent of tassels depends upon the amount of growing time that one would sacrifice by cutting back. No field should be cut back without leaving inserts to see what the effect would have been from not cutting back. Until such experimenting becomes common and much data is accumulated, the question of whether or not to cut back is one of guess work.

I have no data on your Question 10, but I should not be greatly concerned if a field tassels that is to be harvested within six months.

Cause of Tasseling: Maturity, which is brought about by checking growth, from decreased temperatures, decreased light, and which would also be fostered by such factors as decreased irrigation or decreased fertilization at the crucial time. We have positive results for the Waipio Substation and the Makiki Plots, Honolulu, showing that tasseling can be reduced to a negligible amount by fertilization and irrigation.

General: The benefits and losses from cutting back must be worked out for each part of each plantation. The results must not be judged on the number of tassels, but on the sugar ultimately produced. Ten to twenty per cent of the sticks tasseling might be a very discouraging sight, but we have no data to show that this results in a lower sugar yield. Under average conditions, perhaps 30 per cent of tassels would be an even break between no loss and no gain from cutting back. But here I am guessing when we should be experimenting.

Report of the Committee on "Colloids"

THE RELATION OF MILL JUICES TO THE MILLING PROCESS*

By J. D. Bond

According to Zsigmondy[1] "cells, their contents and membranes consist of colloids. The sap of plants is intrinsically a colloidal solution." Cellulose has been defined as a sponge-like structure of colloidal particles held together by certain "unused residual affinities."[2]

Moreover, "the colloids in juices form a very complex system in which the dispersion medium is evidently water. Proteids, polyphenol compounds and related coloring matters, clay, fiber and coarse dispersoids are present. Moreover adsorption complexes are probably formed.[3] It is therefore evident that in the milling process we are dealing with substances primarily colloidal.

Sugar manufacture as an industry producing a vegetable product deals mainly with emulsoids. Patents have been taken out on electro-osmotic purification but no definite information is to be had.[4] Norris[5] found that material from juices was retained by Chamberlain filters.

According to Deerr[6] there is a separation of colloids in juices by heat at about 190° F. The filtration of cane juice in the cold removes from the system the same substances as are eliminated by a rise of temperature to not less than 190° F. It was concluded that colloids in cane juices are irreversible with respect to temperature, reversible to acids and alkalies and are not coagulated by small quantities of electrolytes. These colloids are emulsoids and are negatively charged. More than half of the precipitate obtained in the clarification consists of matter originally present in the colloid state.

In spite of the clearness of filtered, clarified juice, impurities as colloids are present. The fact that excess lime causes more precipitate to form is no proof that the action is strictly chemical because the sulfitation and carbonation processes can be reversed in the laboratory with no change in effect. The acidity of raw juice is reduced by boiling with kieselguhr, most probably due to adsorption. This is true also of decolorizing carbons, but the effect is four or five times as great. Colloids are not entirely removed from juices by kieselguhr, though it gives a clear filtrate, dark in color. Addition of clay or similar colloids which may coagulate other colloids, like proteids, has been suggested.[7]

Colloidal organic silica compounds have been suggested as the cause for poor defecation. These are claimed to be destroyed by superheating before liming.[8]

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* This account includes (a) a brief review of available literature on colloids of the sugar industry; and (b) an account of some original work attempted at the Ewa laboratory.

1 Chemistry of Colloids, p. 5.
2 Paper 25, 700-703 (1919) Minor.
3 La. Bull. 173, p. 7.
4 I. S. J. 23, 400 (1921) Dedek.
5 I. S. J. 21, 71 (1919).
6 I. S. J. 18, 502 (1916).
7 La. Bull. 173, pp. 4-6.
8 I. S. J. 23, 579 (1921) Muller.

The clarification of syrup is based on the phenomena of adsorption by colloidal substances.[9]

Sugar may be hindered in crystallization by protective colloids and this is practised in the manufacture of some candies.[10] A concentrated solution of sugar in water will prevent the precipitation of many inorganic salts including, of particular interest, calcium silicate, lime salts and hydrous oxides of iron. Invert sugar is about seven times as effective as sucrose in holding up hydrous ferric oxide.[11]

Colloids are apparently the source of many difficulties in filtration and of viscous low grades. Inboiling tends to retard crystallization and increase viscosity due perhaps to colloid behavior. Concentrated sugar solutions exhibit the Tyndall effect.[12]

Helderman and Khainovsky[13] from a study of the viscosity of molasses, conclude that the colloids present exert a very great influence. By the use of Norit, they obtained a juice apparently colloid-free. In all cases the quantity of colloids was diminished by treatment with adsorption material. Protective action of colloids in withholding crystallization of inorganic salts, was observed.

"The use of lime alone removes colloids which are not removed by filtration of the juice with kieselguhr. About one-half the amount of total colloids was found in juice that had been limed 1.0—0.2 cc. acidity. From the standpoint of removal of colloids, liming to a low degree of acidity, being careful not to overlime, is probably good practice. Weights of colloids in syrup (from sulfitation process) were reduced approximately one-half by kieselguhr filtration."[14]

The literature contains a considerable number of instances in which attention is called to the problems in the sugar industry connected with colloids. Schneller[15] mentions the problem; Peck[16] suggests that colloids in juice are tannins, albuminoids and pectin bodies; Zerban[17] suggests protein cleavage products; Plausom[18] has devised a method of ultrafiltration which has, however, been adversely criticized; Brewster[19] has done some work on the effect of decolorizing carbons; and many others. The Bureau of Chemistry is at present engaged in a study of the entire subject as to the presence and effect of colloidal matter in sugar house juices and products. Before the next meeting of this Association some of their work will no doubt have been published.

We present in the following a brief account of some work carried out during the grinding season of 1923. No attempt will be made here to discuss the chemical nature or the effect of colloidal matter on our manufacturing process. Rather we will attempt to show the relation of colloidal matter to the well known char-

9 J. Am. Chem. Soc. 27, 86-104 (1905) Noyes.
10 Jerome Alexander from Manual of Industrial Chemistry, Rodgers, p. 1147.
11 Applied Colloid Chemistry, Bancroft, p. 168.
12 I. S. J. 23, 400 (1921) Dedek.
13 I. S. J. 24, 89 (1922).
14 "Report of Work on Some Cane Sugar Manufacturing Problems"—Bureau of Chemistry, Washington, D. C., through courtesy of Dr. H. S. Paine, 1921.
15 La. Planter 56, 44 (1916).
16 I. S. J. 21. 70 (1919).
17 I. S. J. 23, 32 (1921).
18 I. S. J. 23, 680 (1921).
19 J. Ind. Chem. Eng. 13, 10 (1921).

acteristics of mill juices. It must be remembered that our conditions are limited to those obtaining at the factory of the Ewa Plantation and conclusions may or may not apply in other cases.

In any consideration of the milling plant from the standpoint of the boiling house, the most obvious fact is the steady decrease in juice purity from mill to mill. Deerr[20] assigns the fact entirely to differences in purity between rind and pith juices.

In our work, cane was taken from the cars on the track and sampled as fairly as possible as to top, middle and bottom of the stalk. The variety was H 109, canes were sound, weighed from 3-4 kilograms per sample and the tests cover a period of several months. After separation into (a) rind and (b) pith and nodes, the material was reduced in the Athol chopper, weighed and the juice expressed in the familiar hand laboratory press used for the routine determination of fiber in cane. No inconsiderable pressure was exerted since we were able in the same way to express about 1 per cent of residual juice from bagasse. The data is given in Table I.

TABLE I.

	Tests Averaged	Brix	Pol'n.	Sucrose	App. Purity	Gravity Purity	% of Cane	% of Fiber	Fiber % Ash
Pith....	9	20.52	18.78	18.94	91.52	92.30	55.65	6.33	1.75
Rind....	9	21.40	18.50	18.72	86.45	87.48	44.35	21.46	1.63

The maximum difference between the apparent purities of pith (the term "pith" will hereafter [and in Table 1] in our usage include nodes) and of rind juices was 8.1. The lowest observed purity of rind juice was 81. These values are no doubt too high for ordinary practice, but the chief point is the difference in apparent purity between pith and rind juices, which we find to average 5.07 in Table 1. From Table 2 following, the difference between crusher and last mill juice purities for maceration milling is 20.12 points; for dry crushing, 7.86; average for the 1923 crop from control figures, 21.17, with crusher juice purity 84.66.

Table 2 contains data on mill tests. Juices were collected from the discharge rolls of each mill in sequence and analyzed immediately.

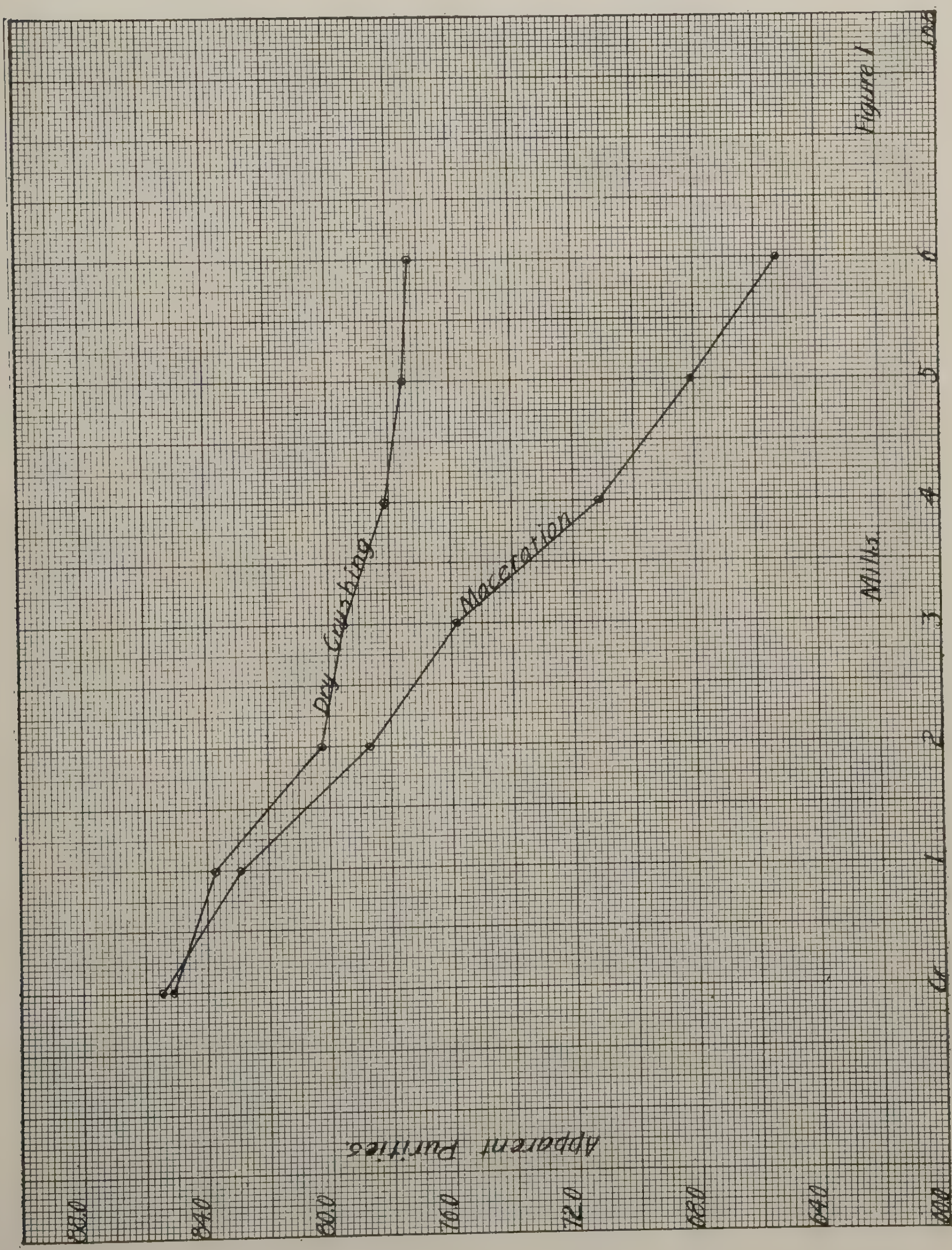
TABLE 2.

Mills	Dry Crushing						Maceration					
	Tests Avgd.	Brix	Pol'n.	Sucr.	App. Purity	Grav. Purity	Tests Avgd.	Brix	Pol'n.	Sucr.	App. Purity	Grav. Purity
Cr.	4	18.95	16.13	16.39	85.13	86.49	12	18 05	15.42	15.67	85.44	86.84
1.	"	18.64	15.62	15.81	83.79	84.82	"	17.12	14.19	14.40	82.91	84.12
2.	"	19.05	15.28	15.47	80.21	81.22	"	11.21	8.82	8.92	78.71	79.54
3.	"	19.06	15.15	15.27	79.49	80.13	"	8.08	6.13	6.17	75.81	76.34
4.	"	18.68	14.59	14.73	78.11	78.84	"	4.08	2.90	2.94	71.18	72.04
5.	"	19.08	14.80	14.96	77.56	78.41	"	2.72	1.85	1.88	68.04	68.96
6.	2*	18.72	14.46	14.62	77.27	78.10	"	1.49	0.97	0.99	65.32	66.44

[20] Cane Sugar, pp. 243-247.

* Two tests only in this series yielded juice in the last mill. For Table 2, the data given for this mill have been calculated from the two tests by proportion.

It is difficult to understand how the purity of last mill juices can be accounted for by rind juice alone. If this were strictly true, dry crushing tests should demonstrate the point quite as well as maceration tests. Moreover, in our cane tests we should have observed at least some instances of very low rind juice purity. We are, of course, considering juices as primarily molecularly dispersed systems, independent of the colloidal nature of fiber. It is reasonable to suppose that the impurities of last mill juices are introduced from rind fiber for the most part since it comprises about 75 per cent of cane fiber.



The curves of Fig. 1 show graphically that we cannot definitely limit the purity of last mill juice in actual practice, but that apparently the purity is dependent upon the treatment of the fiber in the milling process. We have shown in data, which we will not include here, that dilution effects cannot contribute toward the low purity of mill juices, nor, in normal practice is there deterioration of juices.

In Table 3, we have calculated various ratios from our milling data.

TABLE 3.

Mills	Dry Crushing				Maceration.			
	Glucose / Sucrose	S. N. S. / Brix	Glucose / S. N. S.	Grav Pur. — App. "	Glucose / Sucrose	S. N. S. / Brix	Glucose / S. N. S.	Grav. Pur. — App. "
Cr.	6.65	13.51	42.58	1.36	6.13	13.16	39.0	1.40
1.	6.46	15.18	36.04	1.03	5.93	15.88	29.9	1.21
2.	7.04	18.78	30.44	1.01	6.73	20.46	25.5	0.83
3.	7.43	19.87	30.08	0.64	7.55	23.66	23.9	0.53
4.	7.55	21.16	28.10	0.73	8.24	27.96	23.0	0.86
5.	6.93	21.59	25.24	0.85	7.79	31.04	18.6	0.92
6.	6.80	21.90	23.42	0.83	6.82	33.56	13.0	1.12

The ratios are, of course, all multiplied by 100. By "S. N. S." we mean solids not sucrose.

It will be noted that the glucose ratio drops from crusher to first mill due, no doubt, to the first expression of juices from soft tissues which are high in glucose ratio.[21] On further milling, the glucose ratio increases steadily up to and including the fourth mill, after which it drops rapidly through the two succeeding mills. The rise in the ratio may be accounted for by the increasing amount of rind juice expressed in relation to total juice. We know that the glucose ratio of rind juices is somewhat higher than that of pith juices. The drop is, however, not so easily explained unless it be due to selective extracton.

Though S. N. S. per cent Brix is virtually constant in Table 3 for mills 4, 5 and 6 dry crushing, the difference between gravity and apparent purities increases and glucose S. N. S. falls. It would thus appear that while reducing substances are extracted, impurities containing optically active substances are developed. These points are further demonstrated in the case of maceration milling.

The large differences in gravity and apparent purities in the first mills are due probably to levulose in the juices of the softer tissues of the cane, which however, is apparently selectively extracted.

Our data is of course entirely indirect. Direct proof will be difficult. Obviously, these points may be truly characteristic of rind fiber, but this does not alter its significance as far as the milling process is concerned.

In Table 4 are given some data on the ash relations of mill juices. For raw juices, the cotton-filtered juice was taken; for clarified juice, the kieselguhr filtered juice, 30-50 grams of the juices were weighed out in small evaporating dishes, dried at 110° C. and the normal ash determined in the same dishes, using the ash muffle.

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[21] Cane Sugar and its Manufacture, Prinsen Geerligs, p. 83.

TABLE 4.

Mills	Dry Crushing				Maceration			
	Raw Juices		Clarified Juices		Raw Juices		Clarified Juices	
	Ash % Brix	Ash % S.N.S.	Ash % Brix	Ash % S.N.S.	Ash % Brix	Ash % S.N.S.	Ash % Brix	Ash % S.N.S.
Cr.	2.30	17.25	1.41	10.20	2.45	18.60	2.19	16.60
1.	2.88	19.47	2.78	15.93	2.84	19.00	2.98	24.48
2.	3.45	17.47	3.20	15.54	3.86	20.38	4.01	21.30
3.	3.59	17.36	3.38	15.50	5.11	23.30	5.57	25.25
4.	3.85	17.61	3.75	16.51	6.02	20.79	4.07	18.70
5.	3.93	17.45	3.78	15.36	6.46	19.31	4.48	16.74
6.	3.98	17.04	3.13	13.72	8.21	26.10	6.57	23.56

The above data are taken from two complete dry crushing tests and four maceration tests.

A marked difference in ash relations between dry crushing and maceration juices will be noted. The Ash per cent S. N. S. of dry crushing juices is practically constant, whereas Ash per cent Brix increases steadily. In direct contrast, Ash per cent Brix of maceration juices increases rapidly reaching a maximum at the last mill. Ash per cent S. N. S. is variable. These results are moreover carried through to the clarified juice, though somewhat obscured in cases, due to lime.

These facts further substantiate our contention that the characteristics of last mill juices are not intrinsic, but are due to heavy milling in what is practically a water medium.

In Table 5 we give the colloid relations of mill juices. All of the material of the raw juice passing through a cotton filter about one inch thick and not settling after one hour at rest, was classed as colloidal. Obviously, this is not strictly true, but as a means for comparison and for rapid working (which is essential) this procedure was satisfactory. All clarified juices were filtered through kieselguhr after liming the raw juice alkaline to phenolphthalein in the cold and heating to the cracking point. These tests were planned only to give maximum coagulation of colloidal matter. Juices were dialyzed in collodion sacks for 48-72 hours in tap water, followed by 48 hours in distilled water. The colloid solution including coagulated matter was then evaporated on the water bath, finally dried in small evaporating dishes to constant weight and weighed. Weights of dried colloids checking within 5 per cent of each other were accepted.

TABLE 5.

Mills	Dry Crushing				Maceration			
	Raw Juices		Clarified Juices		Raw Juices		Clarified Juices	
	Colloids % Brix	Colloids % S.N.S.	Colloids % Brix	Colloids % S.N.S.	Colloids % Brix	Colloids % S.N.S.	Colloids % Brix	Colloids % S.N.S.
Cr.	1.93	14.63	0.79	5.92	1.88	14.74	0.49	4.07
1.	2.33	15.15	0.67	3.96	2.03	12.71	0.64	4.33
2.	2.36	12.40	0.92	4.78	3.19	14.92	0.98	5.25
3.	2.85	14.29	1.24	5.90	4.83	19.90	1.04	4.55
4.	2.85	13.06	1.25	5.71	8.00	28.53	1.24	4.84
5.	3.00	15.67	1.43	5.97	8.93	28.63	1.48	4.68
6.	3.10	13.27	1.25	5.49	11.87	32.82	2.20	5.89

The above data are taken from three dry crushing tests and nine maceration tests.

Colloids per cent S. N. S. are fairly constant for raw dry crushing juices whereas for raw maceration juices they increase rapidly and exceed, in the last mill, the percentage in the corresponding dry crushing juice by more than 100. Though the two juices are distinctly different as far as colloids in raw juices are concerned, they are comparable in the clarified juices. It is interesting to note, then, that maceration milling actually does increase the impurities in juice to a considerable extent. Since cane fiber is colloidal in nature, it is not unreasonable to expect that impurities, if they are added from the fiber, also be colloidal to some extent.

Colloids are added as a result of mechanical action alone on the fiber, in the presence of a suitable medium, in this case water; and as a result of the breaking down of cell walls followed by flushing with water. This offers a very efficient means for the extraction of protoplasmic matter and other colloidal material confined normally within the cell wall. That colloids may be prepared from cane fiber may readily be demonstrated in the laboratory by continued grinding of prepared bagacillo in the presence of water. Furthermore, from a purely logical viewpoint, there is no reason to believe that the process of milling does not produce particles of fiber of all degrees of subdivision. A considerable amount of fiber from dried bagasse may be dusted through the finest screens.

In one test, Colloid Ash per cent Total Ash in mill juices varied from 6.5 to 16.0 in the raw juice, but dropped in clarified mill juices from 1.1 to 7.2. It increased steadily in the clarified juice throughout the milling process. In the raw juice we may expect soil particles introduced with the cane, which, too, accounts for the high ash content. Colloid Ash per cent Brix varied in the raw juice from 0.23 to 1.07. This being the case, we may correct the gravity purity of juices for both ash and colloids without any considerable error. The figures, will of course be true only in a general way since solids were not determined by drying, but they will show the relative importance of ash and of colloids on the purities of juices. These calculations are given in Table 6.

TABLE 6.

Mills	Dry Crushing			Maceration		
	Gravity Purity	Grav. Pur. Plus Colloids % Bx.	G. Pur. Plus Coll. % Brix Plus Ash % Brix	Gravity Purity	Grav. Pur. Plus Colloids % Bx.	G. Pur. Plus Coll. % Brix Plus Ash % Brix
Cr.	86.49	88.42	90.72	86.84	88.72	91.17
1.	84.82	87.15	90.03	84.12	86.15	88.99
2.	81.22	83.58	87.03	79.54	82.73	86.59
3.	80.13	82.98	86.57	76.34	81.17	86.68
4.	78.84	81.69	85.54	72.04	80.04	86.06
5.	78.41	81.41	85.34	68.96	77.89	84.35
6.	78.10	81.20	85.18	66.44	78.31	86.52

We have here demonstrated that the juices of dry crushing and of maceration tests are actually comparable if colloids and ash are considered. The increased ash and colloid content of last mill juices can then only be derived from the fiber.

The marked similarity in behavior of both colloids and ash in dry crushing and maceration milling may be noted more clearly in the accompanying graphs, Figs. 2 and 3.

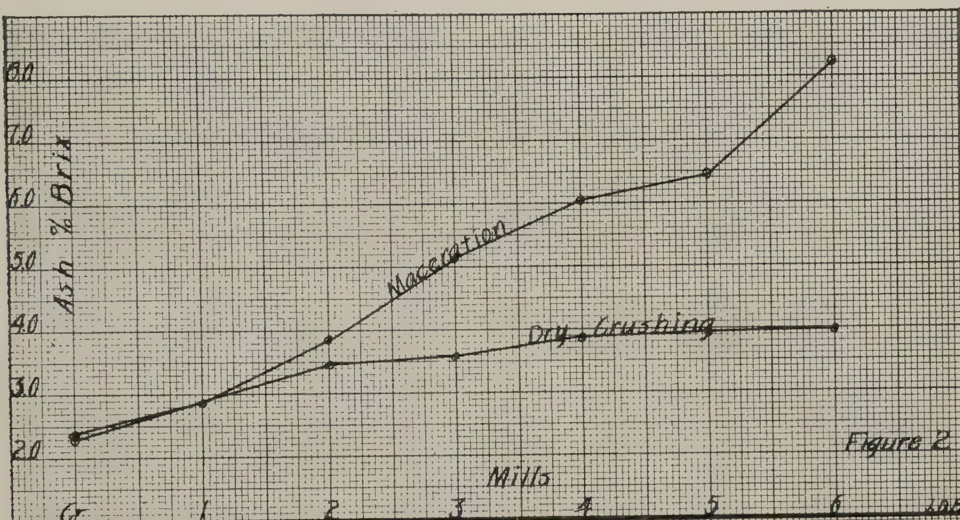

Figure 2

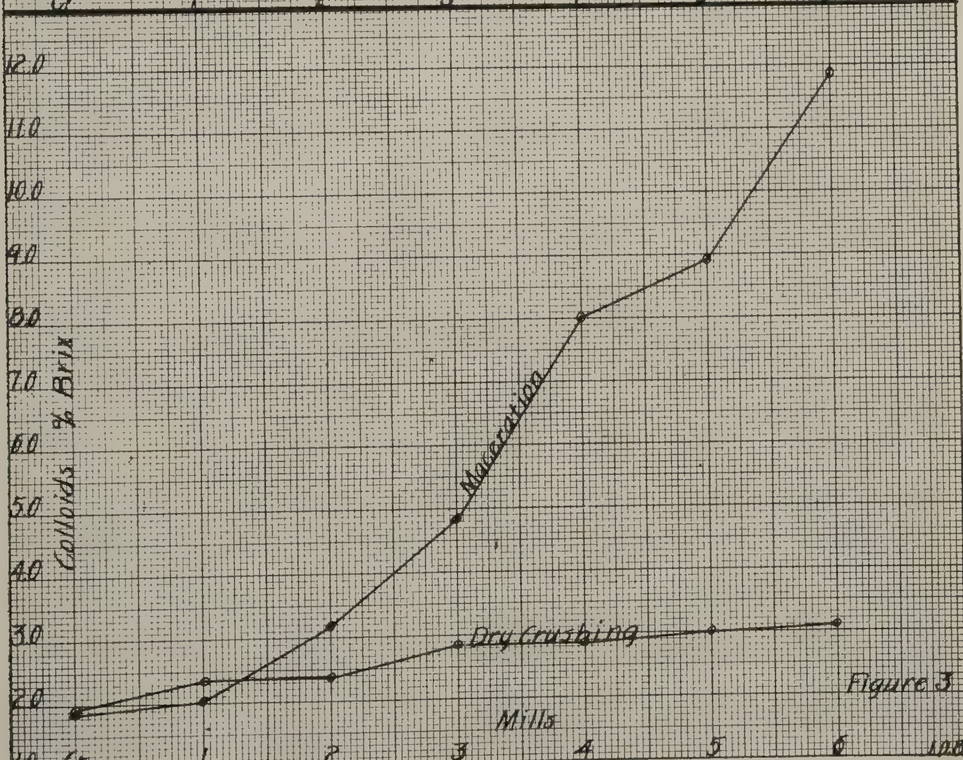

Figure 3

We have noted in dealing with dry crushing juices that those from the last three mills gave considerable difficulty in filtering, apparently irrespective of the amount of lead subacetate added. Indeed it often required a period of 3-4 hours

before sufficient juice could be obtained for a sucrose determination. The clarified, kieselguhr filtered juice of these mills was seldom brilliantly clear as was invariably the case with the earlier mills. Some difficulty is often experienced in routine control work in filtering the juice of the last mill, but does not compare with that obtaining in the case of dry crushing juices. It will be interesting to note Colloids per cent Juice as tabulated in Table 7.

TABLE 7.

Colloids % Juice.

	Dry Crushing		Maceration	
Mills	Raw Juices	Clarified Juices	Raw Juices	Clarified Juices
Cr.	0.39	0.16	0.34	0.10
1.	0.46	0.14	0.35	0.12
2.	0.47	0.17	0.36	0.12
3.	0.57	0.24	0.39	0.09
4.	0.61	0.21	0.35	0.06
5.	0.56	0.28	0.25	0.05
6.	0.66	0.26	0.18	0.04

The Colloids per cent Juice of dry crushing juices are thus seen to be considerably higher in the juices of the last mills than those of the earlier mills. The condition is, however, reversed in the case of maceration juices. It would thus appear in a qualitative way that the filtrability of juices is dependent not so much on the weight of colloidal matter present as upon the nature of these colloids. A case in point is the difference in filtrability of dry crushing juices in the third and fifth mills with the colloid content practically the same. Furthermore, in maceration milling, the last mill juice is the most difficult to filter, yet it contains the lowest percentage of colloids on juice.

The relations between residual and mill juices should develop our viewpoint. By residual juice we mean the juice remaining in the fiber after the expression of juice by a milling unit, and we apply this term generally to any or all mills.

Table 8 gives a summary of tests on mill and residual juices of the last mill. In some tests water was added to the bagasse before pressing in the laboratory, so that the relation of the Brix has no significance. Brix was by pycnometer.

TABLE 8.

Juices	Tests Averaged	Brix	Pol'n.	Apparent Purity
Last Mill	20	1.58	1.09	68.99
Residual	20	1.70	1.24	72.94

Last Mill juices were collected from the discharge roll.

Residual juices are quite generally higher in purity than the last roll juices.

In Table 9, we give data on residual and last mill juices, showing the relation of solids extracted, no water being added to the bagasse before expression in the laboratory press.

TABLE 9.

Juices	Tests Averaged	Brix	Pol'n.	Apparent Purity
Last Mill	5	1.31	0.92	70.18
Residual	5	3.41	2.54	74.44

The brix of residual juice is thus seen to be considerably higher than that of last roll juice. This is not due to adsorption and is probably due to inefficient incorporation of maceration water.

In Table 10, we show colloid relations. In this series, we added to the bagasse in question its own weight of water, thoroughly mixing by hand before extracting the juice in the laboratory hand press.

TABLE 10.

Juices	Tests Averaged	Brix	Pol'n.	Apparent Purity	Colloids % Brix	App. Pur. Plus Colloids % Brix
6 Mill	10	1.77	1.20	67.97	10.22	78.19
6 Residual	10	1.19	0.85	71.48	6.95	78.43
5 Mill	11	3.67	2.60	70.88	6.09	76.97
5 Residual	11	1.76	1.28	72.65	4.72	77.37

These figures show still further that the action of the mills on the fiber produces colloids and that colloids (and probably ash) are directly responsible for the higher purity of residual over last roll juices. It is unfortunate that we cannot show ash relations for these juices.

Summary

Cane tests show an average difference in apparent purity between pith and rind juices of 5.07 points.

The drop in apparent purity from crusher to last mill juice was 7.86 for dry crushing and 20.12 for maceration milling tests.

The low purities of last mill juices cannot be satisfactorily accounted for by the purity of rind juices.

Impurities apparently optically active are introduced into the juice of the last mills. Since approximately 75 per cent of cane fiber is due to the rind, these substances are presumably introduced from the rind.

The ash of mill juices increases steadily from mill to mill, reaching a maximum at the last mill.

The colloids of mill juices increase steadily from mill to mill, reaching a maximum at the last mill.

The characteristics of the last mill are not intrinsic since the corresponding juices of dry crushing tests are not comparable.

Colloidal matter may be prepared from cane fiber in the laboratory.

Juices of dry crushing and maceration milling tests are comparable if colloids and ash are considered.

The higher purities of residual over last roll juices can be accounted for fairly satisfactorily by colloidal matter and perhaps more closely if ash be taken into consideration.

Low purities of last mill juices exist as a direct result of the milling process on cane fiber.

Annual Synopsis of Mill Data, 1923

By W. R. McAllep.

This synopsis includes operating data from all factories in the Association except one. These data represent 99.6% of the 1923 production. Figures in previous synopses have been for operations from the beginning of the grinding season to September 30. This synopsis is for the year from September 30, 1922, to September 30, 1923, and includes unfinished portions of the 1922 crop of eight factories still grinding on September 30, 1922. Three factories had not finished grinding on the corresponding date this year. Data including portions of the 1922 crop and incomplete 1923 data are so indicated in the first of the large tables.

The form of the three large tables is unchanged. The first contains operating data and averages for the last 10 years, the second, mill settings, roller speed, pressures, etc., and the third, surface and juice grooving. The factories are again listed in the order of the average size of the crop for the preceding five seasons.

It has been customary to compare the work with that of previous seasons on the basis of the averages at the bottom of the first of the large tables. Comparisons on this basis have been rendered difficult and unsatisfactory this year by data from two factories operating the Petree process. These factories produced 12% of the crop. Many of these comparisons have been based on mixed juice figures, and the substitution of clarified juice for mixed juice, necessary in tabulating data from these factories has disturbed the mixed juice averages to the extent that they cannot be so used. The press cake averages are also disturbed to the extent that erroneous conclusions would result from comparisons taking these figures at their face value. Data for factories operating this process should be compiled in a separate table. This hardly seems desirable for two factories only, particularly, as the difficulty in securing comparable averages would not be overcome. Table No. 3 containing true averages for 1922 and 1923 for all factories except these two has been compiled. This permits accurate comparisons with 1922 for the factories using the customary process, but does not entirely obviate the difficulty in making comparisons with the work of preceding years. However, by taking into consideration differences between the 1922 averages in this table and corresponding 1922 averages at the foot of the large table, the comparisons, while not as accurate as is desirable, are fairly satisfactory. Comparisons of the figures in Table 3 with corresponding averages for years previous to 1922 are on this basis.

Before leaving this subject it seems desirable to discuss briefly one or two features of the chemical control in cane sugar factories with particular reference to the Petree process. In the absence of a practicable method for determining the sugar in the cane directly, the amount of sugar entering the factory is usually

TABLE NO. 1
VARIETIES OF CANE.

	Yellow Caledonia	H 109	D 1135	Lahaina	Striped Mexican	Striped Tip & Yellow Tip	Rose Bamboo	D 117	Other Varieties
H. C. & S. Co.	..	80	4	13	3	..	..	..	..
Oahu	4	65	14	15	..	..	..	..	..
Ewa	1	93	..	4	..	..	..	..	2
Waialua	16	14	17	17	..	..	4	3	29
Pioneer	..	33	12	17	38	..	..	..	..
Maui Agr.	3	62	6	18	..	..	9	..	2
Olaa	88	..	10	..	..	..	..	..	2
Haw. Sug.	2	24	42	8	..	..	..	..	24
Onomea	94	..	1	..	..	5	..	..	..
Honolulu	50	43	3	4	..	..	..	..	..
Hakalau	98	..	..	..	..	2	..	..	..
Kekaha	2	5	22	69	..	..	..	..	2
Lihue	87	11	2	..	..	..	..	..	..
Haw. Agr.	41	..	9	..	1	..	3	..	46*
Hilo	98	..	1	..	..	1	..	..	..
McBryde	31	46	23	..	..	..	..	..	..
Wailuku	1	46	..	20	28	..	..	..	5
Makee	83	15	..	..	..	..	..	..	2
Laupahoehoe	57	..	5	..	..	35	..	3	..
Honokaa	8	11	78	..	..	3	..	..	..
Pepeekeo	98	..	1	..	..	1	..	..	..
Kahuku	55	35	..	10	..	..	..	..	..
Hamakua	48	1	27	..	..	3	..	21	..
Honomu	95	1	..	..	..	..	..	4	..
Koloa	95	..	5	..	..	..	..	..	..
Paauhau	35	7	55	..	..	2	..	..	1
Waiakea	100	..	..	..	..	..	..	..	..
Hutchinson	31	..	1	..	..	1	67	..	..
Hawi	4	27	16	..	1	52	..	..	..
Waianae	1	75	..	23	..	..	..	..	1
Kaiwiki	44	..	3	..	..	17	1	35	..
Kohala	22	..	35	..	..	41	..	..	2
Kilauea	77	15	..	..	..	..	..	..	8
Kaeleku	100	..	..	..	..	..	..	..	..
Waimanalo	88	12	..	..	..	..	..	..	..
Halawa	35	..	5	..	..	60	..	..	..
Niulii	46	..	10	..	..	44	..	..	..
Waimea	..	41	7	49	..	..	..	..	3
Union Mill	12	..	13	..	..	75	..	..	..
Olowalu	..	34	..	40	26	..	..	..	..
True Average 1923	36.3	30.7	11.2	8.4	3.1	2.8	1.5	1.0	5.0
" " 1922	40.3	21.1	12.2	12.0	2.8	4.3	1.6	1.2	4.5
" " 1921	45.1	15.0	11.0	17.4	3.0	3.0	1.0	1.1	3.4
" " 1920	42.7	9.1	10.0	26.7	2.5	3.5	0.8	1.0	3.7
" " 1919	46.4	6.8	7.2	29.1	1.8	2.9	2.1	1.1	2.6
" " 1918	42.9	4.0	7.5	37.9	0.6	2.0	1.1	0.8	3.2

* White and Yellow Bamboo 12%.

TABLE NO. 2.
COMPOSITION OF CANE BY ISLANDS.

	Hawaii	Maui	Oahu	Kauai	Whole Group
1914					
Polarization	12.75	15.16	14.23	13.62	13.78
Percent Fiber	13.62	11.59	12.44	12.75	12.74
Purity 1st Expressed Juice	88.22	91.02	88.11	87.51	88.71
1915					
Polarization	12.61	15.23	14.29	14.09	13.77
Percent Fiber	13.00	11.44	12.77	12.46	12.51
Purity 1st Expressed Juice	87.86	90.48	87.27	86.99	88.24
1916					
Polarization	12.54	14.62	13.74	13.26	13.45
Percent Fiber	13.22	12.22	12.51	12.86	12.74
Purity 1st Expressed Juice	87.56	89.41	87.15	86.26	87.70
1917					
Polarization	13.31	15.43	13.55	13.13	13.76
Percent Fiber	13.23	11.67	12.25	12.89	12.62
Purity 1st Expressed Juice	88.11	90.69	86.86	86.70	88.02
1918					
Polarization	11.88	14.25	13.50	12.54	12.97
Percent Fiber	13.35	11.53	12.23	12.84	12.50
Purity 1st Expressed Juice	87.27	88.62	86.93	85.88	87.18
1919					
Polarization	12.74	15.12	14.24	13.52	13.74
Percent Fiber	13.07	11.74	12.14	12.61	12.49
Purity 1st Expressed Juice	87.54	88.81	87.00	85.82	87.34
1920					
Polarization	12.86	15.29	13.75	13.07	13.64
Percent Fiber	13.36	11.39	12.65	12.72	12.64
Purity 1st Expressed Juice	87.87	88.94	85.40	86.52	87.24
1921					
Polarization	12.25	14.67	13.72	12.67	13.12
Percent Fiber	13.28	11.82	12.40	13.28	12.80
Purity 1st Expressed Juice	87.18	87.37	85.46	84.07	86.22
1922					
Polarization	12.07	13.95	13.61	13.03	12.97
Percent Fiber	13.16	12.38	12.88	13.22	12.95
Purity 1st Expressed Juice	87.17	87.88	86.18	85.80	86.84
1923					
Polarization	12.09	13.61	12.99	12.94	12.78
Percent Fiber	13.14	12.01	12.86	12.99	12.82
Purity 1st Expressed Juice	87.61	88.65	85.52	86.58	87.05

calculated from the weight and analysis of the mixed juice and the weight and polarization of the bagasse. Undetermined losses in the mill do not appear as losses, but instead reduce the amount of sugar that should be credited to the cane. This method then fails to give the correct figure for sugar entering the factory by the amount of undetermined loss in the mill. All undetermined losses in the boiling house, however, contribute to the undetermined loss shown by the control on this basis. In the Petree process mixed juice figures are not available and the weight and analysis of the clarified juice must be substituted for the mixed juice, in calculating the sugar entering the factory. With the control on this basis not only undetermined losses in the mill, but also undetermined losses up to the point where the clarification is complete, reduce the amount of sugar credited to the cane instead of appearing as losses. Undetermined losses shown by the control on this basis are those occurring subsequent to clarification, that is, in boiling operations. Hawaiian data so far available, for returning settlings to the mill and basing the control on clarified juice indicate that the sugar credited to the cane is less than would be credited operating in the customary manner and basing the control on mixed juice. If the amount of sugar on which the control is based is thus reduced, recovery figures will be too high in comparison with corresponding figures for the usual process. A part, though not all, of the difference in the amount of sugar credited to the cane, is due to a loss in the mill with the Petree process which escapes our methods of control. The amount of bagasse is increased by an amount in proportion to the solids that would otherwise be in the press cake. With both processes, however, the calculated amount of bagasse is the same. The result is that in the Petree process a loss that would otherwise occur in press cake is transferred from the filter presses to the mill where it does not appear as a loss, but instead reduces the amount of sugar that otherwise would be credited to the cane. This varies with the quality of the milling work. With good milling work it may be reduced to the equivalent of the loss in press cake at 0.75% polarization, while with poorer milling work it may become the equivalent of loss in press cake at 2.0% polarization.

On casual examination differences due to changing the basis of the control from mixed juice to clarified juice with settlings returned to the mill may appear negligible. On critical examination of available data, however, differences due to thus changing the basis of the control appear much greater and erroneous conclusions from direct comparison of corresponding figures are probable.

Varieties of Cane

Table 1 shows the proportion of the principle varieties of cane ground at each factory. Averages at the bottom of the table show the proportion of each of these varieties to the entire crop for the past 6 years.

The most noticeable feature is the large increase in the percentage of H 109. In 1922, the proportion of Yellow Caledonia was almost twice that of H 109. This season Yellow Caledonia has decreased to 36.3% while H 109 has increased to 30.7%, leaving Caledonia in first place by a comparatively narrow margin. The

TABLE NO. 3.

True averages of all factories except those now using the Petree process.

	1922	1923
Cane—		
Polarization	12.78	12.65
Fiber	13.04	12.93
Tons per ton sugar	8.78	8.69
Bagasse—		
Polarization	1.73	1.52
Moisture	41.38	41.31
Fiber	56.14	56.48
Polarization % Cane	0.40	0.35
Polarization % pol. of cane	3.14	2.76
Milling Loss	3.08	2.71
Weight % cane	23.22	22.89
First Expressed Juice—		
Brix	18.23	17.99
Polarization	15.79	15.62
Purity	86.63	86.81
"Java ratio"	80.9	81.0
Mixed Juice—		
Brix	13.26	13.12
Polarization	11.08	11.00
Purity	83.51	83.88
Weight % cane	111.56	111.85
Polarization % cane	12.38	12.31
Extraction	96.86	97.24
Extraction ratio	0.24	0.21
Last Expressed Juice—		
Polarization	1.98	1.74
Purity	69.49	68.55
Maceration % cane	34.96	34.73
Syrup—		
Brix	63.02	63.24
Purity	84.80	85.41
Increase in purity	1.29	1.53
Press Cake—		
Polarization	2.07	2.29
Weight % cane	2.51	2.46
Polarization % cane	0.05	0.06
Polarization % pol. of cane	0.41	0.45
Lime used % cane	0.081	0.086
Commercial Sugar—		
Polarization	96.88	96.87
Moisture	0.86	0.80
Weight % cane	11.39	11.51
Polarization % cane	11.04	11.15
Polarization % pol. of cane	86.80	88.33
Polarization % pol. of juice	89.57	90.81
Final Molasses—		
Weight % cane	3.10	2.95
Sucrose % cane	1.05	0.99
Sucrose % pol. of cane	8.25	7.78
Sucrose % pol. of juice	8.51	8.00
Gravity solids	87.93	88.54
Gravity purity	38.64	37.76
Undetermined Losses—		
Polarization % cane	0.23	0.11
Polarization % pol. of cane	1.40	0.68

percentage of Striped Mexican has increased slightly. The proportion of all the principal varieties, except H 109 and Striped Mexican, has decreased. The relatively large decrease in Lahaina has left D 1135 in third place by a comfortable margin.

Minor varieties included in the column "Other Varieties", making up 1% or more of the crop at any factory are:

Variety	% of Total Crop
H 146	0.79
Yellow Bamboo	0.35
H 20	0.15
Badila	0.13
White Bamboo	0.12
H 227	0.12
Total	1.66

Quality of Cane

The composition of the cane by Islands and for the whole group for the past 10 years appears in Table 2. The purity of the first expressed juice is better than in 1922, except on the island of Oahu. For the whole group, it is better than in the two preceding seasons. The polarization of the cane on Hawaii is slightly better than last year. On all other islands it is lower, bringing the average some 0.2 below that of the last year. The fiber is slightly lower than in 1922 on all islands. Compared with the previous season the quality of the cane is slightly better on Hawaii, on Kauai slightly poorer, and on Maui somewhat poorer. On Oahu it is much poorer, amounting to an increase of 0.43 in quality ratio. The average quality of the cane is poorer than in any previous year for which we have a record. Compared with 1922 the increase in quality ratio amounts to 0.12. Almost without exception the cane has been poorer in quality from season to season. In the last ten years there have been but two seasons when this was not the case.

Milling

Milling data indicate a satisfactory improvement over the work of the previous season. Twenty-nine factories report lower bagasse polarization and twenty-two lower moisture in bagasse. Twenty-eight factories report higher extraction against eleven lower, and twenty-seven better milling loss against twelve poorer. Twenty-one factories report less maceration against eighteen more.

Comparing the averages for all factories with 1922, we find the average polarization in bagasse reduced from 1.69 to 1.55, but the average moisture has increased from 41.51 to 41.56. Maceration has increased from 34.75 to 35.12% cane. The milling loss has been reduced from 3.02 to 2.76, an improvement of 0.26. Extraction figures show an improvement from 96.98 to 97.23. Extraction data from Petree process factories, as previously noted, are not directly compara-

ble with data from other factories and on this account the above average is not on a strictly comparable basis with averages for previous years. One Petree process factory reports better and one poorer milling work than last year. Both report poorer work than in preceding seasons. Comparisons of the averages for factories exclusive of these two, appearing in Table 3, indicate greater improvement in milling work than is shown by the figures just noted. Bagasse polarization has been reduced from 1.73 to 1.52, an improvement of 0.21. Moisture in bagasse instead of showing an increase has been reduced from 41.38 to 41.31. Maceration has also been reduced from 34.96 to 34.73. The latter figure is lower than in any year since 1914. The milling loss has been reduced from 3.08 to 2.71, a difference of 0.37, the extraction has been increased from 96.86 to 97.24, an improvement of 0.38, and the extraction ratio has been reduced from 0.24 to 0.21. On the basis of the milling loss these factories report a quality of work very nearly the equivalent of 1921, but better than in any other year. The extraction itself, however, is lower than in 1920 and 1921.

Hydraulic pressure has been increased. In 1922 the average was 65.19 and in 1923, 66.15 tons per linear foot of roller, an increase of approximately one ton. Fifteen factories report heavier pressure, sixteen the same and eight factories lower pressure.

Subsequent to the publication of the synopsis last year, it was suggested that the relatively poor milling results in 1922 might be due to an increase in the grinding rate. To study this factor average grinding rates have been calculated by dividing the total tons of cane by the total hours grinding. These figures follows:

1920	39.34
1921	36.58
1922	39.93
1923	42.03

The grinding rate in 1922 was indeed 9% higher than in the previous year. It was, however, but slightly higher than in 1920 when the extraction was high. There is a further increase of 6% in the 1923 grinding rate. Extraction, however, has improved to almost the 1920 and 1921 standard. Losses in extraction, difficult to avoid, have resulted in individual cases from large increases in the grinding rate. 1923 data, however, indicate that neither the reduced maceration nor the higher grinding rate was necessarily responsible for poor milling work in 1922. It is more probable that the major factor was decreased interest in securing high extraction.

This season there has been a further reduction amounting to 0.19 in the difference in purity between first expressed and mixed juice. Gravity purity of mixed juice has been reported in 1923 Oahu Sugar Company data, while first expressed juice is still on apparent purity basis. The change has affected the averages to the extent of 0.01 and to be on a strictly comparable basis the above figure should be 0.18 instead of 0.19. While Maui Agricultural Company reports on the same basis comparisons with previous years are not affected as this has

been the practice for a number of years. The difference between first expressed and mixed juice purity is the only figure on which inference as to the deterioration in the milling process can be based. Unfortunately several factors affect it to a greater or less extent. The relative purity of the first expressed juice varies according to the proportion of the total juice the sample represents. It may also vary somewhat with different varieties of cane. While direct comparison between individual factories is thus rendered difficult, at the same factories from period to period, particularly when grinding the same variety of cane, and in the averages for all factories from one year to another the relative purity of the first expressed juice is probably sufficiently constant for changes in the purity difference between first expressed and mixed juice to be ascribed to relative changes in mixed juice purity. As a difference of one point in the purity of a juice may be considered fairly close to the equivalent of a difference of one point in the recovery that can be obtained from it, changes in the relative purity of the mixed juice are most significant. Factors affecting the relative purity of the mixed juice are extraction, possibly the amount of maceration, trash on the cane and deterioration in the mill. In 1922 the difference between first expressed and mixed juice purities was 0.34% lower than in the previous year. In that year there was a considerable reduction both in extraction and in maceration. From an analysis of available data presented in the last synopsis, the conclusion was drawn that no considerable part of the reduction in this difference was due to lower extraction or reduction in maceration. Further improvement this year, notwithstanding a material increase in extraction and but little change in maceration, adds weight to this conclusion. The difference this season is smaller than in any of the ten years for which data are available, though in 1914 the extraction was almost two points lower than at present.

Extraction of impurities from field trash and deterioration in the mill are probably the most important factors affecting the relative purity of the mixed juice and thus causing changes in this difference in purity. No figures for the amount of field trash are available, so we can draw no conclusions as to how much this factor has influenced averages from year to year. We do know, however, that well planned efforts to improve mill sanitation have almost invariably resulted in a decrease in the difference between first expressed and mixed juice purities, and that at most of the factories, efforts in this direction have been made in the last two years. The purity difference is now 0.53 smaller than in 1921. In the absence of figures for field trash we do not, of course, know whether all of it or a part only can be ascribed to improvements in mill sanitation. The value of the corresponding increase in recovery, however, would appear ample to repay efforts that may have been made both in reducing field trash and reducing destruction of sugar in the mill. Further improvement is no doubt possible, particularly if satisfactory substitutes are developed for the present mill screens, in which more or less deterioration takes place. The above comments, in so far as they refer to 1923, are based on the averages in Table 3, for the substitution of clarified for mixed juice purities in data from the Petree process factories has

TABLE NO. 4—MILLING RESULTS.

Showing the Rank of the Factories on the Basis of Milling Loss.

Factory	Milling Loss	Extraction Ratio	Extraction	Equipment
1. Onomea	1.09	0.09	98.88	2RC60,S54,12RM66
2. Hakalau	1.09	0.09	98.87	2RC54,12RM9-60,3-66
3. Hilo	1.22	0.10	98.60	K,2RC60,12RM66
4. Pepeekeo	1.92	0.15	98.02	2RC54,9RM60
5. Olowalu	1.98	0.15	98.24	K,3RC48,9RM48
6. Hamakua	2.07	0.17	97.62	K,2RC60,12RM60
7. Lihue	2.20	0.18	97.69	K,2RC78,S72,12RM78
8. Makee	2.25	0.19	97.36	K,2RC72,S72,9RM72
9. Paauhau	2.31	0.20	97.28	2RC60,12RM66
10. Oahu	2.38	0.17	97.85	K(2),2RC78(2),S72(2),12RM78(2)
11. Pioneer	2.45	0.18	97.90	K,2RC72,S72,15RM72
12. Kilauea	2.47	0.22	97.11	K,S,3RC60,9RM60
13. Wailuku	2.55	0.20	97.55	K,2RC72,12RM78
14. Haw. Agr	2.59	0.22	97.07	3RC60,12RM66
15. Waimea	2.60	0.21	97.57	2RC48,12RM42
16. Haw. Sug	2.63	0.18	97.73	K,2RC72,S72,12RM78
17. Honomu	2.67	0.22	97.35	2RC60,9RM60
18. Ewa	2.77	0.22	97.10	K(2),2RC78,18RM78
19. Maui Agr	2.78	0.21	97.56	K(2),3RRC66,18RM66
20. Koloa	2.78	0.23	96.86	K,2RC60,12RM66
21. Waialua	2.82	0.22	97.25	K(2),2RC78,12RM78
22. Kahuku	2.88	0.25	96.09	3RC60,S54,9RM72
23. Hutchinson	2.95	0.27	96.50	2RC60,9RM60
24. Laupahoehoe	2.97	0.24	96.95	K,2RC60,9RM60
25. McBryde	3.24	0.25	96.48	2RC72,S72,9RM84
26. Olaa	3.25	0.26	96.60	K,S72,12RM78
27. Waianae	3.41	0.26	96.68	K(2),12RM60
28. Honokaa	3.42	0.30	96.16	K(2),2RC66,12RM66
29. Kaiwiki	3.52	0.29	96.19	K,2RC60,9RM60
30. H. C. & S. Co.	3.54	0.25	96.98	K(4),2RC78(2),S72(2),12RM78(2)
31. Waiakea	3.68	0.29	96.00	K,S42,2RC60,9RM60
32. Kohala	3.71	0.31	95.95	K(2),3RC60,9RM60
33. Honolulu	3.76	0.28	96.59	K(2),S54,2RC78,9RM78
34. Kekaha	4.10	0.30	96.42	2RC54,9RM60
35. Kaeleku	4.24	0.36	94.86	K,2RC54,9RM60
36. Hawi	4.76	0.35	95.77	K(2),2RC54,12RM54
37. Union Mill	5.41	0.47	93.16	K,9RM60
38. Halawa	5.81	0.50	92.86	K,2RC60,6RM50
39. Niulii	6.43	0.56	91.79	K,9RM54

affected the average mixed juice purity in the large table to the extent that it cannot be used in these comparisons.

Though no factory has this year reported 99 extraction, two factories, Onomea and Hakalau have made new records in milling loss, both reporting 1.09. The previous record, 1.10, was made by Hakalau in 1922. Onomea has made a new record in bagasse polarization, reporting 0.66 against the previous low point, 0.67, reached by Hakalau last year.

Comparisons of Table No. 4 in which the factories are ranked in the order of the size of milling loss, with the corresponding table in the last year's synopsis, shows many changes in relative rank. Hamakua has made the largest change, advancing from thirty-sixth to sixth place. Oahu has advanced from twenty-sixth to tenth, Ewa from thirtieth to eighteenth, and Olowalu from fifteenth to fifth. Other factories that have materially improved their standing are Kahuku, Kaiwiki, Kilauea, Maui Agricultural Company, Waianae, Waiakea and Lihue. H. C. & S. Co. has dropped from fifth to thirtieth place, Koloa from ninth to twentieth, and Hawi from twenty-fourth to thirty-sixth. Honokaa, Kaeleku, Laupahoehoe, Wailuku, Kekaha, Hawaiian Sugar, McBryde, Olaa, Paauhau and Honomu have all dropped several points in relative standing, though four of these, Laupahoehoe, McBryde, Oahu and Paauhau report improved work.

Extra Fuel

Fifteen factories have reported extra fuel in more than small amounts, such as may be required for starting up, or be occasioned by unexpected delays. Eight of the fifteen report smaller amounts of extra fuel than in 1922.

Last season attention was called to the fact that theoretically the bagasse, particularly when supplemented with molasses, should furnish sufficient fuel to maintain a high quality of work and that with proper operation and with equipment suitable for the conditions under which a factory operates this holds true in practice. The writer includes in the term "proper operation" a sufficient supply of cane to grind at a reasonable capacity.

Data reported this season confirm this conclusion. In addition to Pioneer, Ewa may be cited as a factory where no extra fuel is now required though formerly large quantities were burned. Though no extra fuel was burned at this factory in 1922, it was not then cited as an example, for in that year a part of the milling machinery was not available during a considerable portion of the season, preventing a fair comparison. This year with all the milling machinery in operation, fuel requirements have been met without the use of extra fuel. Two only of the eleven factories ranking highest in milling work have reported any extra fuel. One is handicapped by an inadequate supply of cane. At the other extra fuel consumption has been reduced to between 20 and 25% of the 1922 requirement. It is planned to greatly reduce or eliminate the present requirement by correcting known defects that could not well be attended to during the grinding season. The greater number of factories using extra fuel are among those reporting comparatively poor milling work. Of the first twenty

TABLE NO. 5.
GRAVITY SOLIDS AND SUCROSE BALANCES.

Factory	Gravity Solids per 100 Gravity Solids in Mixed Juice				Sucrose per 100 Sucrose in Mixed Juice			
	Press Cake	Commercial Sugar	Final Molasses	Undetermined	Press Cake	Commercial Sugar	Final Molasses	Undetermined
H. C. & S. Co.	0.6	84.9	13.7	0.8	0.1	93.5	6.0	0.4
Oahu	2 9	79.4	16.1	1.6	0.3	92.0	7.3	0.4
Ewa	5.6	73.0	18.6	2.8	0.3	90.0	8.3	1.4
Waialua	5.4	73.9	18.1	2.6	0.6	89.2	8.9	1.3
Pioneer	3.5	78.9	15.8	1.8	0.3	92.3	6.8	0.6
Maui Agr.	...	83.9	14.1	2.0	...	94.9	6.5	—1.4
Onomea	5.0	78.7	14.7	1.6	0.1	92.4	6.3	1.2
Hakalau	3.8	79.0	14.5	2.7	0.1	92.4	6.2	1.3
Haw. Agr.	4.2	77.3	17.1	1.4	0.8	88.3	7.8	3.1
Hilo	5.2	77.6	15.0	2.2	0.3	92.4	6.9	0.4
McBryde	4.4	75.4	21.0	—0.8	0.3	89.3	9.4	1.0
Wailuku	4.8	78.3	16.1	0.8	0.2	91.9	7.4	0 5
Makee	2.7	73.4	18.5	5.4	0.3	87.9	8.5	3.3
Laupahoehoe	4.3	77.4	18.1	0.2	0.2	90.2	8.5	1.1
Honokaa	5.7	74.6	18.6	1.1	0.4	89.9	9.0	0.7
Pepeekeo	3.2	79.4	14.0	3.4	0.1	92.7	5.8	1.4
Hamakua	8.6	72.2	14.1	5.1	1.7	87.9	7.5	2.9
Honomu	5.0	78.0	15.1	1.9	0.4	92.2	6.5	0.9
Paauhau	6.5	75.5	17.3	0.7	0.5	90.8	7.8	0.9
Waiakea	5.2	76.0	14.0	4.8	0.5	89.6	6.7	3.2
Hutchinson	5.1	74.3	17.9	2.7	0.3	88.2	8.8	2.7
Kilauea	3.0	69.9	17.6	9.5	0.9	85.5	8.7	4.9
Union Mill	10.2	70.6	17.9	1.3	1.5	87.8	9.6	1.1

factories in Table 4, less than a third reported extra fuel, against almost a half of the nineteen factories in the lower half of the table.

It would seem desirable in factories requiring extra fuel to make a survey of operating methods and equipment to determine what factors are responsible. In some cases comparatively minor changes in methods and equipment will result in marked improvement. In others faulty design renders satisfactory solution of the problem more difficult. The writer believes that, save in exceptional cases, it will be found more economical to correct faulty conditions than to continue expenditures for extra fuel, particularly as the quality of the work is usually poorer during periods of fuel shortage.

Both factories operating the Petree process report extra fuel. A large reduction over previous requirements was made at one factory. At the other the amount is much larger than last year, but in somewhat near the same proportion as in preceding seasons.

Sucrose Balances and Chemical Control

Gravity solids and sucrose balances for factories reporting sucrose data are in Table 5. Two additional factories have reported sucrose data this year making a total of 23 factories with the control on a sucrose basis.

Table 6 is a comparison of recoveries with the calculated available based on polarization figures. Table 7 is a similar calculation for the factories reporting the necessary data on the more reliable true sucrose basis. It should be noted that 100% in these tables is not necessarily the maximum possible recovery, but rather the amount of sugar that a calculation indicates should be recovered with the reported syrup, sugar and molasses purities. Figures for "recovery on available" are then principally checks on the accuracy of the chemical control, though low figures may be due to losses.

Defects in control based on polarization have been commented on in previous synopses. Data in these tables further emphasize the inadequacy of control on this basis. The figure for undetermined loss is deceptively low. The arithmetical average for the undetermined losses on a sucrose basis for the factories listed in Table 5 is 0.7 higher than is shown by polarization figures. Comparisons of other data in Table 5 with corresponding polarization figures, and comparisons of corresponding figures in Tables 6 and 7 disclose further discrepancies in figures based on polarization. Chemical control based on polarization has served a valuable purpose in making apparent the comparatively large avoidable losses that were formerly common in factory operation. As a result such losses have been reduced through more efficient factory operation. With the present standard of factory work greater refinement in the control is essential and the discrepancies inherent in a control based on polarization should be eliminated. Formerly a sucrose control was hardly practicable, particularly at the smaller factories, for the determinations were time consuming and required a high degree of skill. Methods have now been simplified to the extent that it is practicable to have the determinations made by good laboratory assistants and it has been estimated by

TABLE NO. 6.

APPARENT BOILING-HOUSE RECOVERY.

Comparing percent available sucrose in the syrup (calculated by formula) with percent polarization actually obtained.

Factory	Available *	Obtained	Recovery on Available
H. C. & S. Co.	92.77	94.80	102.2
Oahu	91.76	92.25†	100.5
Ewa	90.42	91.47	101.2
Waialua	90.10	90.27	100.2
Pioneer	92.42	92.78	100.4
Maui Agr.	91.39	94.88 †	103.8
Olaa	91.02	91.16	100.2
Haw. Sug.	92.72	93.15	100.5
Onomea	93.33	92.80	99.4
Hakalau	92.73	93.26	100.6
Kekaha	92.89	90.66	97.6
Lihue	90.87	92.01	101.3
Haw. Agr.	92.73	89.75	96.8
Hilo	91.95	92.84	101.0
McBryde	91.83	90.31	98.3
Wailuku	92.44	92.43	100.0
Makee	89.46	89.00	99.5
Laupahoehoe	92.11	90.59	98.3
Honokaa	90.74	90.51	99.7
Pepeekeo	92.97	93.13	100.2
Kahuku	89.63	90.09	100.5
Hamakua	90.17	89.81	99.6
Honomu	93.02	93.00	100.0
Koloa	87.56	87.93	100.4
Paauhau	92.42	91.28	98.8
Waiakea	91.62	90.65	98.9
Hutchinson	90.51	89.26	98.6
Hawi	91.01	85.82	94.3
Waianae	88.58	88.46	99.9
Kaiwiki	90.45	90.68	100.3
Kohala	91.09	91.32	100.3
Kilauea	87.33	87.98	100.7
Kaeleku	88.29	87.48	99.1
Halawa	88.95	85.76	96.4
Niulii	89.99	89.42	99.4
Waimea	90.06	91.26	101.3
Union Mill	89.67	90.01	100.4
Olowalu	88.88	82.99	93.4

* In order to calculate the available sucrose it is necessary to estimate the gravity purity of the syrup and sugar. Data from factories determining both apparent and gravity purities indicate that the average correction necessary is the addition of 0.8 to the apparent purity of the syrup and 0.3 to the apparent purity of the sugar. When the moisture in the sugar has not been reported 1% has been taken. 38 has been used when the gravity purity of the molasses has not been reported.

† Sucrose.

TABLE NO. 7.

TRUE BOILING-HOUSE RECOVERY.

Comparing percent sucrose available and recovered.

Factory	Available	Obtained	% Recovery on Available
H. C. & S. Co.	93.16	93.59	100.5
Oahu	91.76	92.28	100.6
Ewa	90.53	90.27	99.7
Waialua	89.81	89.74	99.9
Pioneer	92.35	92.58	100.2
Maui Agr.	91.39	94.90	103.8
Onomea	93.29	92.49	99.1
Hakalau	92.78	92.49	99.7
Haw. Agr.	93.14	89.01	95.6
Hilo	91.71	92.68	101.1
McBryde	91.74	89.57	97.6
Wailuku	92.29	92.08	99.8
Makee	89.54	88.16	98.5
Laupahoehoe	92.07	90.38	98.2
Honokaa	90.58	90.26	99.6
Pepeekeo	92.83	92.79	100.0
Hamakua	89.72	89.42	99.7
Honomu	92.67	92.57	99.9
Paauhau	92.26	91.30	99.0
Waiakea	91.60	90.05	98.3
Hutchinson	90.75	88.47	97.5
Kilauea	86.65	86.28	99.6
Union Mill	89.80	89.14	99.3

TABLE NO. 8.

PERCENT MOLASSES PRODUCED ON THEORETICAL.

H. C. & S. Co.	90.7	Laupahoehoe	97.2
Oahu	90.9	Honokaa	93.5
Ewa	88.8	Pepeekeo	81.4
Waialua	88.7	Kahuku	83.5
Pioneer	89.3	Hamakua	74.6
Maui Agri.	87.3	Honomu	92.2
Olaa	92.9	Koloa	81.8
Haw. Sug.	90.3	Paauhau	96.6
Onomea	89.2	Waiakea	75.0
Hakalau	84.6	Hutchinson	86.8
Kekaha	92.5	Hawi	97.9
Lihue	87.7	Kaiwiki	86.3
Haw. Agr.	91.0	Kohala	92.9
Hilo	86.6	Kilauea	71.0
McBryde	105.8	Kaeleku	89.9
Wailuku	96.7	Union Mill	93.6
Makee	78.0	Olowalu	91.5

factory chemists that the time required for the necessary determinations does not exceed from one-half hour to one hour per day. The control at 60% of the factories is now on a sucrose basis and it would seem most desirable for the remaining factories to make the change.

Molasses data is a feature of the chemical control that is gradually improving in accuracy from year to year. This year but one factory failed to report molasses purity. All but four reported molasses weights. At twenty-two factories producing 70 to 75% of the total quality, the molasses was weighed instead of the weight being calculated from measurements.

Data for molasses produced on theoretical, Table 8, have been more consistent from year to year since this table was first calculated. On the whole, even though one factory reports more than 100%, the figures may be considered somewhat more consistent than last year. The theoretical amount of molasses could be calculated on a much more logical basis than that used at present if a sufficient number of the factories reported sucrose data for all calculations to be made on this basis.

Boiling House Work

Clarification: Data for clarification indicate a continuation of the improvement that was noted last year in this phase of the work. Twenty-three factories report larger increases in purity, three report the same and eleven smaller increases. No factories reported deceases in purity from mixed juice to syrup either in 1922 or 1923, though for several seasons prior to these, such decreases had been reported. The tendency to use a larger amount of lime, shown by the figures for the preceding two years, has continued this season. The increase has been from 0.084 to 0.087% on cane. The average increase in purity from mixed juice to syrup (Table 3) is 1.53 against 1.29 in 1922. This is the largest increase in purity since 1918. The syrup purity is higher than in any year since 1919. Somewhat less than one-third of the improvement over last season may be credited to higher initial purities. The remainder is due to better results in clarification and a smaller decrease in purity from first expressed to mixed juice.

Lack of mixed juice analyses has prevented including Petree process factories in the above comparison. They can be included in comparisons of first expressed juice and syrup purities, though such comparisons are affected by factors other than clarification. Twenty-eight factories report smaller, one the same and ten larger differences between first expressed juice and syrup purities. Averages for the past three years are:

1921	2.32
1922	1.88
1923	1.40

The latter figure is lower than in any year for which averages are available, except 1914 and 1918, in both of which years the figure was also 1.40. The im-

provement compared with 1921 is 0.92. Compared with 1922, it is 0.48. Improvements in purity as large as this are the equivalent of material improvements in recovery.

Both Petree process factories reduced this difference between first expressed juice and syrup purities in comparison with the previous year, H. C. & S. Co. to the extent of 0.60, and Maui Agricultural Company to the extent of 1.45. At the latter factory the lime used was increased from 0.075 to 0.10, or 33%.

Filtration: Data for filter press operation show much less satisfactory conditions. While figures at the foot of the large table indicate lower polarization and a smaller quantity of press cake, this is due to data from Petree process factories, accentuated because at these factories the filter press losses in 1922 were over twice as large as the average. Data in Table 3 show an increase in the polarization of the press cake from 2.07 in 1922 to 2.29 in 1923. The quantity has decreased from 2.51 to 2.46% on cane. The decrease in quantity has not been enough to offset the increase in polarization and the loss per cent polarization of cane has increased from 0.41 to 0.45. Present filtration practice is far from satisfactory and improvements are greatly needed.

Evaporation: The brix of the syrup was 63.26 and that of the mixed juice 13.13, indicating 79.24% evaporation; the highest figure yet recorded. The brix of the syrup was 0.11 lower than in 1922, but higher than in any other year for which averages are available.

Commercial Sugar: The commercial sugar has increased slightly in polarization the average being 96.90 against 96.88 last year. This is the highest polarization since 1913.

Averages for moisture in sugar indicate a marked improvement in this phase of the work. The moisture content has been reduced from 0.87 to 0.83. The corresponding deterioration factors are 0.279 and 0.268. Further improvement in this respect is desirable for available data indicate that deterioration is possible in Hawaiian sugars with a deterioration factor exceeding 0.25, while it has not been detected in sugar with a lower deterioration factor. Averages in Table 3 show a much greater improvement in this respect than is shown by averages for all of the factories. The deterioration factor has been reduced from 0.276 in 1922 to 0.256 in 1923. The latter figure is fairly close to what may be considered a safe point.

Low grade work has also greatly improved this year. Twenty-five factories report lower molasses purity against ten reporting higher. Kahuku has established a new record, finishing the season with an average of 33.16 gravity purity. A part of the 1922 crop ground subsequent to September 30, is included in the above. The average for the 1923 crop exclusive of this is still better, 32.92. The previous low average for a season was 33.95 reported from Pepeekeo in 1920.

The average gravity purity, 37.90, is also a new record. It is 0.85 lower than the 1922 average and .05 lower than the previous low point reached in 1919. The quantity of molasses per cent cane, and also the loss per cent polarization in cane and per cent polarization in mixed juice has been materially reduced. The percentage of molasses on cane is smaller than in any year since 1915. The only season since 1916 in which the loss per cent polarization in cane and per cent polarization in mixed juice was smaller than this year is 1919.

Opinions have been expressed that alkaline clarification renders it more difficult to attain low molasses purities. Such opinions are not without foundation, for a high glucose content renders it somewhat easier to attain a given molasses purity, and with acid clarification there will be a greater amount of glucose because of inversion of sucrose during the manufacturing process. We know that if the density is sufficiently high sugar will crystalize from molasses till the gravity purity is below 30 and this information defines the problem of securing low final molasses as the mechanical one of separating the molasses from the crystals. That the gravity purity of the final molasses is lower this year than ever before, though the amount of lime is the largest so far reported, is a strong indication that, while the average molasses purity is considerably above the point to which we know the crystallization of sugar will reduce it, such factors as the one under discussion are of decidedly secondary importance.

Recovery

While the quality of the cane has decreased from year to year, in the last two seasons this has been due to a smaller percentage of sugar and not to lower purity. As the purity has increased, from the standpoint of boiling house operations, the quality has improved, and other factors being equal, improved recovery would be expected. The total recovery or recovery per cent polarization in cane is higher than in any previous year while the boiling house recovery or recovery per cent polarization in mixed juice is higher than in any year since 1913. While the 1923 recovery figures are not exactly comparable with previous figures because of data from Petree process factories, the discrepancies are not great enough to affect the accuracy of the above statments.

In the years prior to 1913, in which higher boiling house recoveries were reported, the control was usually based on juice measurements rather than on weights, and as it has usually been found on changing from measuring to weighing that the amount of sugar previously calculated as entering the factory was less than it should have been, there is reason to consider earlier figures high in comparison with later data. While in these years, the juice in the cane was of higher purity than at present and higher boiling house recoveries might reasonably be expected, it is not at all improbable that actually the boiling house recovery this year as well as the total recovery is better than in any previous season.

Compared with 1922 the improvement in boiling house recovery has been much greater than is accounted for by the higher purity in the cane. Data in Table 3, which are on a strictly comparable basis, indicate an improvement of

1.24 in boiling house recovery. Analysis of the figures indicate that 15% of the improvement may be credited to better initial purity and the remainder about equally divided between smaller undetermined loss, lower molasses purity and increase in syrup purity due to better increase in purity in clarification and smaller decrease from first expressed to mixed juice purity.

Figures in the same table indicate an improvement over last year in total recovery of 1.53. This is considerably greater than the 1.24 improvement in boiling house recovery. Higher extraction this season is responsible for the difference.

The improvement in factory work is shown by a comparison of quality ratio with tons of cane actually required to make a ton of sugar. Quality ratios for 1922 and 1923 are 8.45 and 8.57 indicating an increase of 0.12 of a ton in the estimated amount of cane required to make a ton of sugar. Instead of being increased the actual amount required has been reduced from 8.62 to 8.56, a reduction of 0.06 of a ton, that is, there has been a net gain of 0.18 of a ton in the amount of cane required to make a ton of sugar due to better factory work. Incidentally it will be noted that the quality ratio calculation corresponds very closely with present average practice, 8.57 tons being indicated against 8.56 actually required.

The trend of factory work this year has been most satisfactory. Compared with last season higher extraction has been secured, though it is still slightly below that secured in 1920 and 1921. The improvement in extraction has been accompanied by a smaller drop in purity from first expressed to mixed juice. Better results have been secured in clarification and there has been a material decrease in the purity of the final molasses. The increase in recovery is larger than is accounted for by the above factors and higher initial purity, a result principally due to reduction in undetermined losses. Another material improvement is the reduction in moisture in commercial sugar, thus reducing the probability of loss between factory and refinery. The only feature of the work showing an unsatisfactory trend is filter press operation and in this phase of the work operating methods and equipment are greatly in need of improvement.

Experimental work has shown that it is possible to secure the expected recovery from the last increments of extraction and that inversion of sucrose takes place at reactions that were formerly considered safe. Other experiments have pointed the way to better increases in purity during clarification. Critical examination of the figures in synopses for the last few years, furnishes convincing proof that with proper factory operation the expected recovery is actually secured from the last increments of extraction and that the actual gain in recovery of sugar agrees reasonably well with the expected gain from larger increases in purity during clarification and reduction of inversion through carrying juices at the proper reaction.

Figures were presented in the Annual Synopsis for 1921 showing that for two seasons recoveries had been decreasing to a greater extent than could be attributed to changes in the quality of the cane and that this was due to poorer

boiling house work. A criticism of the milling might well have been made also, for in these years the difference between the first expressed and mixed juice purities had been increasing. This year, data can be presented for the past two seasons showing much more satisfactory conditions.

The following figures have been tabulated for convenient reference:

	Extraction	Purities: First Expressed	Purities: Mixed Juice	Purities: Syrup	Total Recovery	Molasses Loss	Undetermined Juice
1921....	97.43	86.22	82.77	83.90	85.86	9.27	1.97
1922....	96.98	86.84	83.73	84.96	87.02	8.16	1.27
1923....	97.23	87.05	84.12	85.65	88.77	7.58	.48

As previously noted some of the 1923 figures are not on a comparable basis with those of previous years, and it is necessary to take the probable size of the discrepancies into consideration in making comparisons. It has been necessary to calculate the mixed juice purities from the ratio of mixed juice to first expressed juice and syrup purities in Table 3. The probable accuracy is one or two in the second decimal place. The figure for extraction is high, possibly by as much as .03 or .04. The undetermined loss is too low. If we assume the same improvement in this respect over 1922 at the Petree process factories as at the others, the average would be 0.55 instead of 0.48. The recovery is too high, possibly by as much as 0.21. It is unfortunate that these discrepancies, preventing direct comparisons exist, yet by taking into consideration their probable maximum size, which has been arrived at through careful consideration of all available data, fairly satisfactory comparisons can be made.

Examination of the figures shows that throughout this two year period there has been improvement in first expressed juice purity, greater improvement in mixed juice purity and still greater improvement in the purity of the syrup. Undetermined losses have steadily decreased as have also losses in molasses. Material increases in the total recovery have resulted. The 1923 extraction while better than in 1922 is still between 0.2 and 0.25 below the 1921 standard.

In comparison with 1921 the improvement in 1923 first expressed juice purity is 0.83. On the basis of the 1921 quality of boiling house work this improvement in initial purity corresponds to an increase in recovery from 85.86 in 1921 to 86.52 in 1923. The 1923 recovery taking the figure at its face value is 88.77, or 102.60% or 86.52. If we reduce the 1923 recovery figure by the maximum it was estimated that data from Petree process factories could have affected it, it is still 88.56, or 102.36% of 86.52. This indicates that notwithstanding slightly lower extraction than in 1921, more efficient factory work, previously discussed in detail, has resulted in an improvement in recovery somewhere between a minimum of 2.36 and a maximum of 2.60%.

If we place a net value of $100 per ton on sugar, according to the above, more efficient factory work in 1923 has produced additional sugar to a value of between $2.36 and $2.60 for each ton of sugar that would have been produced

with the 1921 quality of work. If we estimate the "cost of manufacture" at $7.50 per ton, in comparison with 1921, this extra production has paid for about one-third of the cost of factory operation.

Increased production to the above extent is closely confirmed by comparisons on a quality ratio basis. Data for quality ratio and tons cane required per ton of sugar follow:

	Quality Ratio	Tons cane required	Net gain over 1921 Tons	Per cent
1921	8.414	8.605	.....	....
1922	8.448	8.617	0.022	0.36
1923	8.573	8.556	0.208	2.42

The gain shown in the above tabulation, 2.42%, coincides closely with that arrived at in the previous calculation, and is between the minimum and maximum values there shown.

In Table 9 the factories are ranked on the basis of a comparison of actual and calculated recoveries. Similar tables in previous synopses were termed "factory efficiency." Comparisons on this basis have never been entirely satisfactory because due allowances could not be made in the calculations for differences in syrup purities, and factories with low syrup purities were discriminated against. This was because the standard for molasses purity was below the point attained in practice. A few years ago the standard was changed from 35 to 30 gravity purity, thus accentuating the discrepancies. This year discrepancies have been reduced and the comparison placed on a much fairer basis by adopting as the standard 37.5, a figure approximately the present average molasses purity. On this basis the work of a factory reducing the molasses to 37.5 gravity purity and having no other losses in the boiling house would be represented by 100 in the second column. As it is possible to reduce molasses far below this purity, the figure 100 then, has no particular significance with reference to the possible quality of the work. With good low grade work and high extraction it is possible for a factory to have figures over 100 in both the second and third columns. While the discrepancies have been reduced, comparisons on this basis are not yet entirely free from criticism. This table is again presentd, however, for want of a better method for ranking the factories on the basis of the entire factory work.

The calculations in this synopsis have been made by Mr. A. Brodie assisted by Mr. H. A. Cook.

TABLE NO. 9.

COMPARISON OF ACTUAL AND CALCULATED RECOVERIES.

The factories are arranged in the order of the ratio of their recovery to that resulting from 100% extraction, reducing the molasses to 37.5 gravity purity, and eliminating all other losses. Factories reporting a recovery of over 101% of the available (Table No. 6) are omitted from this tabulation.

No.	Factory	Milling	Boiling House	Over All
1	Hakalau	98.87	101.13	100.14
2	Hilo	98.60	100.60	99.37
3	Pepeekeo	98.02	101.04	99.25
4	Onomea	98.88	99.81	98.86
5	Pioneer	97.90	100.61	98.78
6	Kahuku	96.09	102.06	98.65
7	Oahu	97.85	99.95	98.15
8	Honomu	97.35	100.29	97.92
9	Haw. Sug.	97.73	99.90	97.87
10	Wailuku	97.55	99.43	97.42
11	Makee	97.36	99.14	96.85
12	Paauhau	97.28	98.63	96.25
13	Waialua	97.25	98.58	96.23
14	Kilauea	97.11	98.64	96.15
15	Olaa	96.60	98.98	96.15
16	Koloa	96.86	98.63	96.13
17	Kohala	95.95	99.31	95.65
18	Honokaa	96.16	98.65	95.25
19	McBryde	96.48	98.22	95.15
20	Laupahoehoe	96.95	97.53	94.82
21	Kaiwiki	96.19	98.23	94.75
22	Waianae	96.68	97.59	94.71
23	Waiakea	96.00	97.69	94.20
24	Hutchinson	96.50	96.94	94.12
25	Hamakua	97.62	95.80	93.74
26	Kekaha	96.42	96.41	93.33
27	Haw. Agr.	97.07	95.51	92.95
28	Kaeleku	94.86	96.65	92.00
29	Union Mill	93.16	96.98	90.85
30	Olowalu	98.24	91.96	90.57
31	Niulii	91.79	97.48	89.99
32	Hawi	95.77	92.23	88.76
33	Halawa	92.86	92.72	86.50

TABLE NO. 10.

SUMMARY OF LOSSES.

FACTORY	POUNDS POLARIZATION PER TON OF CANE						POLARIZATION PER 100 CANE						POLARIZATION PER 100 POLARIZATION OF CANE							FACTORY
	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Syrup Purity	
H. C. & S. Co..	8.4	0.2	16.6	...	—2.2	23.0*	0.42	0.01	0.83	...	—0.11	1.15*	3.02	0.09	5.92	...	—0.81	9.22*	87.65	H. C. & S. Co.
Oahu........	5.8	0.8	19.6	...	1.2	27.4†	0.29	0.04	0.98	...	0.06	1.37†	2.15	0.26	7.14	...	0.43	9.98†	86.80	Oahu
Ewa.........	7.2	0.8	20.2	...	0.2	28.4*	0.36	0.04	1.01	...	0.01	1.42*	2.90	0.36	8.15	...	0.10	11.51*	82.96	Ewa
Waialua....	7.2	1.4	22.8	...	1.8	33.2	0.36	0.07	1.14	...	0.09	1.66	2.75	0.57	8.73	...	0.68	12.73	84.60	Waialua
Pioneer......	5.8	0.8	18.2	...	1.2	26.0	0.29	0.04	0.91	...	0.06	1.30	2.10	0.31	6.65	...	0.40	9.46	86.16	Pioneer
Maui Agr....	6.6	...	17.0	...	—3.6	20.0*†	0.33	...	0.85	...	—0.18	1.00*†	2.44	...	6.36	...	—1.36	7.44*†	87.19	Maui Agr.
Olaa.........	8.4	1.2	20.0	...	0.8	30.4	0.42	0.06	1.00	...	0.04	1.52	3.40	0.49	8.14	...	0.35	12.38	85.8	Olaa
Haw. Sug....	6.4	2.4	18.4	...	0.4	27.6	0.32	0.12	0.92	...	0.02	1.38	2.27	0.85	6.47	...	0.17	9.76	86.30	Haw. Sug.
Onomea......	2.8	0.2	15.6	...	2.0	20.6	0.14	0.01	0.78	...	0.10	1.03	1.12	0.07	6.30	...	0.81	8.90	87.34	Onomea
Honolulu....	9.2	0.4	30.8	0.8	...	...	0.46	0.02	1.54	0.04	...	...	3.41	0.15	11.48	0.31	...	...	85.23	Honolulu
Hakalau.....	2.8	0.4	15.4	...	1.2	19.8	0.14	0.02	0.77	...	0.06	0.99	1.13	0.13	6.15	...	0.51	7.92	85.87	Hakalau
Kekaha......	9.8	2.2	19.8	...	4.6	36.4	0.49	0.11	0.99	...	0.23	1.82	3.58	0.82	7.23	...	1.70	13.33	87.27	Kekaha
Lihue........	5.6	0.6	18.8	...	0.4	25.4*	0.28	0.03	0.94	...	0.02	1.27*	2.31	0.25	7.62	...	0.17	10.35*	83.24	Lihue
Haw. Agr....	7.0	1.8	18.2	...	5.4	32.4	0.35	0.09	0.91	...	0.26	1.61	2.93	0.76	7.69	...	2.19	13.57	87.61	Haw. Agr.
Hilo.........	3.4	0.6	16.4	...	0.6	21.0	0.17	0.03	0.82	...	0.03	1.05	1.40	0.27	6.81	...	0.22	8.70	85.91	Hilo
McBryde.....	9.0	0.8	23.8	...	0.2	33.8	0.45	0.04	1.19	...	0.01	1.69	3.52	0.28	9.22	...	0.10	13.12	85.54	McBryde
Wailuku.....	6.4	0.4	19.0	...	0.2	26.0	0.32	0.02	0.95	...	0.01	1.30	2.45	0.19	7.29	...	0.08	10.01	87.0	Wailuku
Makee.......	6.4	0.8	20.0	...	5.6	32.8	0.32	0.04	1.00	...	0.28	1.64	2.64	0.30	8.34	...	2.34	13.62	83.21	Makee
Laupahoehoe	7.6	0.4	20.8	...	2.2	31.0	0.38	0.02	1.04	...	0.11	1.55	3.05	0.17	8.27	...	0.84	12.33	86.95	Laupahoehoe
Honokaa.....	8.6	1.0	19.4	...	1.0	30.0	0.43	0.05	0.97	...	0.05	1.50	3.84	0.42	8.66	...	0.42	13.34	84.89	Honokaa
Pepeekeo....	4.8	0.4	14.2	...	2.4	21.8	0.24	0.02	0.71	...	0.12	1.09	1.98	0.13	5.72	...	1.00	8.83	86.0	Pepeekeo
Kahuku......	9.0	2.2	19.4	...	2.6	33.2	0.45	0.11	0.97	...	0.13	1.66	3.91	0.91	8.36	...	1.08	14.26	80.78	Kahuku
Hamakua....	5.8	4.0	18.0	...	5.8	33.6	0.29	0.20	0.90	...	0.29	1.68	2.38	1.63	7.39	...	2.40	13.80	86.14	Hamakua
Honomu.....	6.6	0.8	15.8	...	1.0	24.2	0.33	0.04	0.79	...	0.05	1.21	2.65	0.34	6.39	...	0.40	9.78	86.3	Honomu
Koloa........	7.8	2.6	24.4	...	4.0	38.8	0.39	0.13	1.22	...	0.20	1.94	3.14	1.09	9.92	...	1.64	15.79	81.6	Koloa
Paauhau.....	6.2	1.0	17.4	...	2.0	26.6	0.31	0.05	0.87	...	0.10	1.33	2.72	0.44	7.61	...	0.83	11.60	86.1	Paauhau
Waiakea......	10.0	1.2	16.2	...	6.0	33.4	0.50	0.06	0.81	...	0.30	1.67	4.00	0.45	6.49	...	2.44	13.38	86.34	Waiakea
Hutchinson..	7.6	0.8	18.8	...	3.6	30.8	0.38	0.04	0.94	...	0.18	1.54	3.50	0.35	8.64	...	1.69	14.18	85.52	Hutchinson
Hawi........	11.6	1.6	29.4	...	7.6	50.2	0.58	0.08	1.47	...	0.38	2.51	4.23	0.57	10.75	...	2.75	18.30	86.40	Hawi
Waianae.....	8.6	1.2	...	...	29.0	38.8	0.43	0.06	...	...	1.45	1.94	3.32	0.49	...	...	11.10	14.91	83.70	Waianae
Kaiwiki......	9.2	2.2	19.2	...	2.0	32.6	0.46	0.11	0.96	...	0.10	1.63	3.81	0.93	8.03	...	0.85	13.62	85.21	Kaiwiki
Kohala.......	9.8	1.6	19.4	...	0.6	31.4	0.49	0.08	0.97	...	0.03	1.57	4.05	0.68	7.98	...	0.28	12.99	85.05	Kohala
Kilauea......	6.6	2.0	19.6	...	6.6	34.8	0.33	0.10	0.98	...	0.33	1.74	2.89	0.90	8.65	...	2.91	15.35	81.6	Kilauea
Kaeleku......	12.0	1.6	24.6	...	3.0	41.2	0.60	0.08	1.23	...	0.15	2.06	5.14	0.64	10.50	...	1.30	17.58	83.36	Kaeleku
Halawa......	16.6	2.0	...	...	30.2	48.8	0.83	0.10	...	...	1.51	2.44	7.14	0.85	...	...	13.10	21.09	85.21	Halawa
Niulii........	19.0	0.8	...	...	22.4	42.2	0.95	0.04	...	...	1.12	2.11	8.21	0.33	...	...	9.68	18.22	85.04	Niulii
Waimea......	6.2	1.0	...	...	21.6	28.8*	0.31	0.05	...	...	1.08	1.44*	2.41	0.41	...	...	8.52	11.34*	83.57	Waimea
Union Mill..	15.8	3.2	20.8	...	0.2	40.0	0.79	0.16	1.04	...	0.01	2.00	6.94	1.39	9.05	...	0.12	17.40	84.97	Union Mill
Olowalu.....	4.6	0.6	32.4	...	11.2	48.8	0.23	0.03	1.62	...	0.56	2.44	1.76	0.19	12.37	...	4.31	18.63	83.7	Olowalu

* A comparison of the available sucrose in the juice with the amount recovered in the boiling-house indicates that there is probably an error in some of the results reported from this factory.

† Sucrose.

Sugar Prices.

96° Centrifugals for the Period September 16 to December 15, 1923.

Date	Per Pound	Per Ton	Remarks
Sept. 19, 1923	6.905¢	$138.10	Cubas, 6.78, 7.03.
" 20..........	7.28	145.60	Cubas.
" 24..........	7.41	148.20	Cubas.
" 25..........	7.53	150.60	Cubas.
" 27..........	7.78	155.60	Cubas.
Oct. 23..........	7.405	148.10	Cubas, 7.53, 7.28.
" 24..........	7.34	146.80	Cubas.
" 25..........	7.28	145.60	Cubas.
" 31..........	7.09	141.80	Cubas.
Nov. 2..........	6.91	138.20	Cubas.
" 9..........	7.16	143.20	Cubas.
" 21..........	7.3433	146.86	Cubas, 7.28, 7.34, 7.41.
Dec. 10..........	7.28	145.60	Cubas.
" 12..........	7.335	146.70	Cubas, 7.41, 7.26.

ANNUAL SYNOPSIS OF MILL DATA--SHOWING RESULTS FROM 39 HAWAIIAN FACTORIES FOR CROP OF 1923

Factory	Factory No.	Milling Plant (Sizes in Inches)	CANE: Polarization	% Fiber	Tons cane per ton commercial sugar	Tons ground per hour	Tonnage ratio	BAGASSE: Polarization	% Moisture	% Fiber	Pol. per 100 cane	Pol. per 100 pol. of cane	Pol. per 100 Fiber "Milling Loss"	Weight per 100 cane	Factory No.	FIRST EXPRESSED JUICE: Brix	Polarization	Purity	Pol. of cane x 100 / Polarization	MIXED JUICE: Brix	Polarization	Purity	Weight per 100 cane	Pol. per 100 cane	Pol. per 100 pol. of cane "Extraction"	Extraction Ratio	LAST EXPRESSED JUICE: Polarization	Purity	MACERATION WATER: Weight per 100 cane	Dilution % normal juice	Factory No.	Clarified juice purity
H. C. & S. Co.**	6	K 4', 2RC78(2), S72(2), 12RM78(2)	13.98	11.95	7.55	52.51‡	1.49	1.95	42.14	55.08	0.42	3.02	3.54	21.68	6	19.38	17.30	89.28	80.8	13.75	12.06	87.68	112.36	13.56	96.98	0.25	2.58	70.14	34.04	38.11	6	87.68
Oahu	20	K 2, 2RC78(2), S72(2), 12RM78(2)	13.69	12.35	7.89	51.16‡	1.45	1.36	40.91	57.04	0.29	2.15	2.38	21.63	20	19.17	16.61	86.65	81.6	13.47	11.45*	85.00	116.95	13.40	97.85	0.17	0.95	66.20	38.58	37.05	20	85.86
Ewa††	5	K 2, 2RC78, 12RM78	13.59	12.97	8.85	68.84	1.40	1.50	43.43	54.24	0.36	2.90	2.77	23.91	5	18.68	15.84	84.77	78.2	13.30	10.82	81.35	111.17	12.03	97.10	0.22	1.10	64.50	35.08	32.41	5	83.25
Waialua††	17	K 2, 2RC78, 12RM78	13.07	12.73	8.48	54.21	1.54	1.34	43.11	54.63	0.36	2.75	2.82	23.32	17	18.57	16.16	87.0	80.9	13.05	10.86	83.2	117.09	12.71	97.25	0.22	2.25	68.0	40.41	38.70	17	85.2
Pioneer	10	K, 2RC72, S72, 15RM72	13.73	11.77	7.84	75.00	2.08	1.34	43.23	54.85	0.29	2.10	2.45	21.45	10	19.60	17.27	88.11	79.5	15.22	12.96	85.14	103.70	13.44	97.90	0.18	0.84	70.05	25.15	26.32	10	86.36
Maui Agr.**	21	K 2, 3RC66, 18RM66	13.45	11.76	7.82	60.07	1.70	1.41	46.88	50.78	0.33	2.44	2.78	23.16	21	17.99	15.84	88.05	84.9	12.16	10.54*	86.68	124.53	13.12	97.56	0.21	1.54	60.87	47.69	47.94	21	86.27
Olaa	36	K, S72, 12RM78	12.33	12.97	9.00	54.72	1.94	1.73	44.28	53.17	0.42	3.40	3.25	21.24	36	16.96	14.75	87.0	83.6	12.94	10.87	84.0	109.54	11.91	96.60	0.26	0.95	66.4	33.78	31.1	36	85.8
Haw. Sug.	16	K, 2RC72, S72, 12RM78	14.27	12.30	7.51	40.54	1.15	1.48	41.78	56.18	0.32	2.27	2.63	21.88	16	19.23	16.86	87.68	84.6	13.38	11.41	85.28	122.15	13.91	97.73	0.18	1.72	72.57	44.04	43.05	16	85.92
Onomea	34	2RC66, S54, 12RM66	12.41	12.79	8.54	39.50	1.57	0.66	38.04	60.98	0.14	1.12	1.09	20.97	34	16.49	14.59	88.48	85.1	12.17	10.42	85.63	117.72	12.27	98.88	0.09	1.36	67.06	38.70	36.85	34	87.17
Honolulu	13	K 2, S54, 2RC78, 9RM78	13.45	12.22	8.59	36.9	1.31	2.14	39.96	56.86	0.46	3.41	3.76	21.50	13	19.21	16.36	85.2	82.2	13.13	10.80	82.25	120.33	12.99	96.59	0.28	1.36	67.4	41.83	42.7	13	85.3
Hakalau	7	2RC54, 12RM [illegible]	12.45	12.88	8.41	31.52	1.51	0.68	36.57	62.44	0.14	1.13	1.09	20.62	7	16.79	14.73	87.73	84.5	11.42	9.74	85.20	126.42	12.31	98.87	0.09	1.23	69.10	47.05	47.02	7	86.01
Kekaha	25	2RC54, 12RM60	13.68	11.95	8.12	29.98	1.76	2.30	40.51	56.11	0.49	3.58	4.10	21.29	25	18.55	16.65	89.76	82.2	13.85	11.94	86.21	110.50	13.19	96.42	0.30	1.94	72.66	31.79	31.05	25	87.30
Lihue	27	K, 2RC78, S72, 12RM78	12.32	12.88	8.76	54.71	1.55	1.25	41.25	56.82	0.28	2.31	2.20	22.67	27	18.51	15.79	85.3	78.0	13.43	11.06	82.4	108.76	12.03	97.69	0.18	1.72	64.7	31.43	31.43	27	82.8
Haw. Agr.††	30	RC60, 12RM66	11.82	13.57	9.49	46.18	1.83	1.51	39.76	58.28	0.35	2.93	2.59	22.91	30	16.71	14.80	88.57	79.9	13.73	11.93	86.89	96.23	11.48	97.07	0.22	2.48	76.07	19.17	14.71	30	87.33
Hilo	33	K, 2RC60, 12RM66	12.02	13.78	8.80	39.46	1.57	0.73	39.17	59.76	0.17	1.40	1.22	23.06	33	16.06	13.89	86.49	86.5	11.86	9.99	84.23	118.63	11.85	98.60	0.10	1.63	68.48	41.68	39.63	33	84.38
McBryde	12	RC72, S72, 9RM54	12.90	13.97	8.07	36.88	1.13	1.82	41.32	56.09	0.45	3.52	3.24	24.89	12	18.72	16.37	87.45	78.8	12.67	10.60	83.66	117.42	12.44	96.48	0.25	2.28	70.37	42.31	42.23	12	84.19
Wailuku	2	K, 2RC72, 12RM78	13.05	12.51	8.26	38.44	1.09	1.48	39.73	58.00	0.32	2.45	2.55	21.56	2	18.67	16.70	89.4	78.1	13.78	11.74	85.2	108.46	12.73	97.55	0.20	1.43	65.0	30.02	27.87	2	86.3
Makee	14	K, 2RC72, S72, 9RM72	12.03	14.02	9.34	52.51	2.19	1.27	41.88	56.35	0.32	2.64	2.25	24.88	14	18.07	15.35	84.95	78.4	13.60	11.21	82.43	104.46	11.71	97.36	0.19	3.66	68.80	29.34	25.37	14	83.36
Laupahoehoe	41	K, 2RC66, 9RM60	12.57	12.92	8.77	27.19	1.65	1.76	38.35	59.27	0.38	3.05	2.97	21.83	41	16.82	14.92	88.70	84.2	12.24	10.44	85.29	116.72	12.19	96.95	0.24	2.87	73.97	38.55	38.81	41	86.75
Honokaa	35	K 2, 2RC66, 12RM66	11.25	12.65	9.88	39.82	1.58	1.84	43.61	53.83	0.43	3.84	3.42	23.50	35	16.40	14.26	86.95	78.9	12.19	10.17	83.43	106.41	10.82	96.16	0.30	1.97	71.90	29.91	29.2	35	84.35
Pepeekeo	19	2RC54, 9RM60	12.37	12.81	8.60	25.95	1.56	1.14	38.94	59.52	0.24	1.98	1.92	21.52	19	16.97	14.89	87.7	83.1	13.09	11.09	84.7	109.34	12.13	98.02	0.15	1.98	74.2	30.86	28.34	19	85.5
Kahuku††	43	RC60, S54, 9RM72	11.62	13.73	9.73	23.16	0.97	1.63	40.87	56.59	0.45	3.91	2.88	27.84	43	17.71	14.67	82.83	79.2	12.87	10.19	79.17	109.57	11.16	96.09	0.25	1.59	64.11	37.41	33.48	43	81.38
Hamakua	15	K, 2RC60, 12RM60	12.26	14.15	9.18	27.15	1.30	1.16	42.34	56.07	0.29	2.38	2.07	25.21	15	18.06	16.05	88.87	76.2	13.29	11.22	84.42	106.39	11.94	97.62	0.17	1.95	72.76	31.61	27.46	15	85.57
Honomu	37	RC66, 9RM60	12.63	12.24	8.71	25.07	1.50	1.60	37.87	59.90	0.33	2.65	2.67	20.43	37	16.81	14.78	87.9	83.4	12.24	10.27	83.9	116.83	12.00	97.35	0.22	2.25	71.7	37.26	37.34	37	85.4
Koloa	38	K, 2RC60, 12RM66	12.29	13.85	9.48	30.75	1.22	1.54	42.02	55.43	0.39	3.14	2.78	25.04	38	18.61	15.55	83.6	79.0	13.33	10.60	79.5	112.34	11.91	96.86	0.23	0.99	60.3	37.38	35.71	38	81.5
Paauhau	24	2RC60, 12RM66	11.47	13.57	9.55	31.16	1.24	1.57	38.59	59.42	0.31	2.72	2.31	22.78	24	16.95	14.89	87.8	77.0	12.50	10.44	83.5	106.59	11.16	97.28	0.20	2.00	69.0	29.67	27.60	24	85.3
Waiakea	3	K, S42, RC60, 9RM60	12.45	13.76	8.65	25.22	1.51	2.02	42.34	54.84	0.50	4.00	3.68	24.72	3	18.02	15.67	86.96	79.6	13.31	11.25	81.53	106.45	11.98	96.00	0.29	2.83	71.65	31.17	29.15	3	85.78
Hutchinson††	31	[illegible]	10.92	12.01	10.71	26.63	1.60	1.65	41.55	55.85	0.38	3.50	2.95	23.12	31	15.38	13.44	87.39	81.3	11.42	9.55	83.63	110.30	10.53	96.50	0.27	1.38	63.59	33.42	32.32	31	85.31
Hawi	26	K 2, 2RC54, 12RM54	13.72	12.20	8.60	23.10	1.37	2.63	41.15	55.23	0.58	4.23	4.76	22.08	26	18.34	16.30	88.90	84.2	15.20	13.11	86.25	100.23	13.14	95.77	0.35	4.34	73.60	22.31	19.9	26	86.70
Waianae	9	K 2, [illegible] RM60	13.06	12.70	8.71	24.45	1.46	1.92	41.00	56.25	0.43	3.32	3.11	22.58	9	19.26	16.55	85.93	78.9	13.12	10.73	81.80	117.69	12.63	96.68	0.26	3.26	69.96	40.27	39.73	9	83.66
[illegible]††	32	K, 2RC66, 9RM60	11.56	12.98	9.35	25.47	1.53	2.01	49.13	57.12	0.46	2.81	3.52	22.69	32	17.77	15.48	87.11	77.3	12.60	10.59	84.05	108.64	11.51	96.19	0.29	2.73	72.99	31.33	30.40	32	85.55
Kohala	40	K 2, [illegible]	12.11	13.23	9.16	25.86	1.55	1.99	43.56	53.66	0.49	4.05	3.71	24.65	40	16.88	14.63	86.67	82.8	11.95	9.95	83.26	116.78	11.62	95.95	0.31	1.59	71.62	41.43	40.42	40	85.12
[illegible]††	23	[illegible]	11.37	[illegible]	[illegible]	24.75	1.48	1.42	40.00	57.89	0.33	2.89	2.47	23.10	23	17.86	15.03	84.2	75.6	12.98	10.39	80.0	106.29	11.04	97.11	0.22	1.85	67.3	29.39	....	23	81.0
Kaeleku	47	K, 2RC[illegible], 19RM60	11.72	[illegible]	[illegible]	24.06	1.50	2.59	40.49	56.31	0.60	5.14	4.24	23.25	47	16.97	14.50	85.45	80.8	13.05	10.75	82.38	103.41	11.12	94.86	0.36	4.43	75.21	28.66	27.66	47	83.95
Halawa	29	K, 2RC60, 6RM50	11.57	14.19	10.78	15.81	1.59	3.13	42.17	53.84	0.83	7.14	5.81	26.36	29	16.53	14.19	85.84	81.4	13.03	10.93	83.88	98.08	10.72	92.86	0.50	6.46	78.49	24.44	23.71	29	84.91
Niulii	39	K, 2RM54	11.56	14.78	10.20	15.24	1.70	3.09	47.85	48.09	0.95	8.21	6.13	30.73	39	16.41	14.01	85.38	82.5	12.78	10.65	83.36	99.60	10.61	91.79	0.56	4.36	76.10	30.33	28.41	39	84.54
Waimea	4	[illegible] RM42	12.73	11.79	8.52	[illegible]	[illegible]	1.75	38.27	[illegible]	0.31	2.43	2.60	19.77	4	17.93	15.23	84.9	83.6	13.57	11.34	83.56	109.52	12.42	97.57	0.21	2.76	69.5	29.29	28.9	4	83.53
Union Mill††	11	[illegible]	11.51	13.74	10.1	[illegible]	1.27	2.83	43.67	52.27	0.79	6.81	5.41	27.82	11	17.29	14.86	85.94	77.5	12.84	10.58	82.37	101.43	10.73	93.16	0.47	4.84	73.3	27.25	26.96	11	84.1
Olowalu	18	K, [illegible]	13.08	11.68	9.08	17.10	1.60	1.18	38.67	59.76	0.23	1.76	1.98	19.56	18	18.49	16.09	87.0	81.3	13.30	11.00	82.7	116.82	12.85	98.24	0.15	2.25	66.8	36.38	35.11	18	83.6
True Av. 1923			12.78	12.82	[illegible]	....	....	1.55	41.56	56.18	0.35	2.77	2.76	22.80	1923	18.09	15.75	87.05	81.1	13.13	11.06	84.27	112.32	12.42	97.23	0.22	1.79	68.31	35.12	....	1923	....
" " 1922			12.97	[illegible]	[illegible]	....	....	1.69	41.51	56.05	0.39	3.02	3.02	23.69	1922	18.44	16.01	86.84	81.0	13.46	11.27	83.73	111.48	12.58	96.98	0.23	1.93	69.13	34.75	....	1922	....
" " 1921			13.12	12.80	8.61	....	....	1.50	41.20	56.58	0.34	2.57	2.64	22.58	1921	18.74	16.16	86.22	81.2	13.25	10.97	82.77	116.50	12.79	97.43	0.20	1.68	65.89	39.30	....	1921	....
" " 1920			[illegible]	12.04	8.12	....	....	1.56	41.05	56.68	0.35	2.55	2.75	22.29	1920	19.32	16.85	87.24	80.9	13.48	11.31	83.87	117.35	13.29	97.45	0.20	1.65	68.20	39.95	....	1920	....
" " 1919			13.74	12.49	7.93	....	....	1.67	41.57	56.05	0.37	2.70	2.97	22.27	1919	19.17	16.74	87.34	82.0	13.39	11.29	84.29	118.29	13.37	97.30	0.22	1.70	68.53	40.80	....	1919	....
" " 1918			12.97	12.50	8.51	....	....	1.59	42.70	55.04	0.36	2.79	2.90	22.74	1918	18.26	15.92	87.18	81.3	12.92	10.85	83.99	116.05	12.60	97.21	0.22	1.56	69.52	38.99	....	1918	....
" " 1917			13.76	12.62	[illegible]	....	....	1.78	42.26	55.31	0.41	2.95	3.22	22.83	1917	19.14	16.85	88.02	81.6	13.48	11.45	84.83	116.53	13.34	97.05	0.23	1.71	71.15	39.39	....	1917	....
" " 1916			13.45	12.74	8.16	....	....	1.81	42.49	54.98	0.42	3.13	3.30	23.19	1916	18.64	16.34	87.70	82.3	13.17	11.14	84.59	116.99	13.03	96.87	0.25	1.75	71.71	39.85	....	1916	....
" " 1915			13.77	12.51	7.98	....	....	2.17	43.87	53.07	0.51	3.72	4.09	23.57	1915	18.87	16.65	88.24	82.7	14.03	11.89	84.75	111.44	13.26	96.30	0.30	1.96	73.88	35.04	....	1915	....
" " 1914			13.78	12.74	8.13	....	....	2.49	45.72	50.87	0.62	4.52	4.89	25.04	1914	18.86	16.73	88.71	82.4	14.19	12.16	85.70	108.14	13.15	95.46	0.36	2.28	74.96	33.64	....	1914	....

Factory	Factory No.	SYRUP: Brix	Purity	Increase in Purity	PRESS CAKE: Polarization	Weight per 100 cane	Pol. per 100 cane	Pol. per 100 pol. of cane	LIME USED (Weight Per 100 Cane): In Juice	In Settlings	Total	COMMERCIAL SUGAR: Polarization	% Moisture	Weight per 100 cane	Pol. per 100 cane	Pol. per 100 pol. of cane	Pol. per 100 pol. of juice	Total weight in thousand tons	Factory No.	FINAL MOLASSES: Weight per 100 cane	Sucrose per 100 cane	Sucrose per 100 pol. of cane	Sucrose per 100 pol. of juice	Gravity solids	Gravity purity	True purity	OTHER KNOWN LOSSES: Pol. per 100 cane	Pol. per 100 pol. of cane	UNDETERMINED LOSSES: Pol. per 100 cane	Pol. per 100 pol. of cane	Factory No.
H. C. & S. Co.**	6	63.07	87.65	[illegible]	3.87	0.31	0.01	0.09	[illegible]	[illegible]	0.10	96.94	0.92	13.34	12.83	91.78	94.63	44	6	2.39	0.83	[illegible]	6.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oahu	20	63.62	86.80	1.80*	1.94	1.80	0.04	0.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	92.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ewa††	5	66.61	86.06	1.61	1.87	2.38	0.04	0.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	88.19	91.13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	[illegible]	[illegible]
Waialua††	17	64.67	84.80	1.40	2.68	2.80	0.07	0.57	[illegible]	[illegible]	0.10	96.60	0.75	11.79	11.41	87.26	89.73	28	17	3.12	1.14	8.73	8.98	91.99	39.77	....	....	....	0.09	[illegible]	[illegible]
Pioneer	10	66.68	86.16	1.02	1.33	3.14	0.04	0.31	[illegible]	[illegible]	[illegible]	97.41	0.66	12.76	12.43	90.54	92.49	28	10	2.84	0.91	6.65	6.79	89.26	36.00	....	....	....	0.06	[illegible]	[illegible]
Maui Agr.**	21	64.38	87.19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	97.40*	0.64	12.78	12.45	92.56	94.88	20	21	2.43	0.85	6.36	6.51	87.87	40.07	43.69	....	....	−0.18	[illegible]	[illegible]
Olaa	36	63.13	85.8	1.8	3.83	1.59	0.06	0.49	[illegible]	[illegible]	[illegible]	97.10	0.92	11.11	10.80	87.61	90.69	26	36	2.95	1.00	8.14	8.43	86.90	39.1	....	....	....	0.04	[illegible]	[illegible]
Haw. Sug.	16	66.80	86.30	1.02	3.33	2.39	0.12	0.85	0.06	0.01	0.07	96.72	0.68	13.31	12.88	90.25	92.34	22	16	2.87	0.92	6.47	6.62	87.63	[illegible]	[illegible]	....	....	[illegible]	[illegible]	[illegible]
Onomea	34	65.09	87.34	1.71	0.40	2.22	0.01	0.07	[illegible]	[illegible]	[illegible]	97.19	0.85	11.71	11.35	91.70	92.74	18	34	2.43	0.78	6.30	6.37	88.96	36.16	....	....	....	0.10	0.81	[illegible]
Honolulu	13	56.54	85.23	2.98¶	0.62	3.19	0.02	0.15	[illegible]	[illegible]	0.12	....	....	....	....	....	....	15¶	13	4.33	1.54	11.48	11.88	89.63	39.74	....	0.04	0.31	...	...	[illegible]
Hakalau	7	66.16	85.87	[illegible]	0.47	3.29	0.02	0.13	[illegible]	[illegible]	[illegible]	96.38	1.01	11.90	11.47	92.08	93.14	14	7	[illegible]	0.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Kekaha	25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87.67	89.89	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lihue	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	91.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Haw. Agr.††	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	86.43	89.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hilo	33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	91.29	92.59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
McBryde	12	59.33	85.51	1.88	2.00	1.78	0.04	0.28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	86.88	90.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wailuku	2	58.37	87.0	1.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	89.99	92.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Makee	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	86.38	88.72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Laupahoehoe	41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87.67	90.43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Honokaa	35	62.42	84.89	1.46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	86.66	90.12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pepeekeo	19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	91.17	93.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Kahuku††	43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	85.74	89.23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hamakua	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	86.20	88.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Honomu	37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	92.67	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Koloa	38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	84.21	86.94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Paauhau	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.14	88.29	90.87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Waiakea	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	86.62	90.23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hutchinson††	31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	85.82	88.94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hawi	26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	85.31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Waianae	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	85.09	88.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]††	32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	86.38	89.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Kohala	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87.01	90.68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]††	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	84.65	87.17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Kaeleku	47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	82.42	86.89	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Halawa	29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	78.91	84.98	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Niulii	39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81.78	89.09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Waimea	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.29	88.66	90.87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Union Mill††	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.51	[illegible]	88.66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Olowalu	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
True Av. 1923	1923	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	91.28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " 1922	1922	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	89.68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " 1921	1921	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.21	85.86	88.03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " 1920	1920	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.87	87.35	89.56	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " 1919	1919	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	88.57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " 1918	1918	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87.91	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " 1917	1917	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12.06	87.93	90.58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1917
" " 1916	1916	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.80	87.98	90.84	..	1916	2.90	0.98	7.41	7.64	87.63	39.25	....	....	....	....	....	1916
" " 1915	1915	[illegible]	[illegible]	[illegible]	1.84	1.89	0.05	0.35	[illegible]	[illegible]	[illegible]	96.40	0.98	12.52	12.07	87.65	91.03	..	1915	2.81	0.97	6.98	7.22	87.36	39.69	....	....	....	....	....	1915
" " 1914	1914	60.93	87.31	1.61	1.76	1.78	0.03	0.23	[illegible]	[illegible]	[illegible]	96.66	0.93	12.30	11.89	86.56	90.95	..	1914	2.80	0.99	7.12	7.43	87.87	40.40	....	....	....	....	....	1914

* Sucrose.
† Refined sugar.
‡ For one mill only.
¶ Probably influenced by low grade sugar in syrup.
§ 1923 crop unfinished.
** Petree process.
†† Balance of 1922 crop included.

CANE MILL DATA, SEASON OF 1923

Factory	Factory No.	MILLING PLANT (Sizes in Inches)	Revolving Knives, First Set: Number	First Set: Distance Apart Inches	First Set: Distance from Conveyor Inches	First Set: Revolutions per Minute	Second Set: Number	Second Set: Distance Apart Inches	Second Set: Distance from Conveyor Inches	Second Set: Revolutions per Minute
H. C. & S. Co...	6	K(2),2RC34x78,S72,12RM34x78..	36	7 1/4	24	1200	56	4 1/2	16	1200
" " ...	6	K(2),2RC34x78,S72,12RM34x78...	36	7 1/4	24	1200	56	4 1/2	16	1200
Oahu........	20	K,2RC34x78,S72,12RM34x78.....	28	5	22	490	..	....	....	....
"	20	K,2RC34x78,S72,12RM34x78....	28	4 1/2	22	690	..	....	....	....
Ewa..........	5	K(2),2RC32x78,18RM34x78.....	72	2	15	580	70	2	3	580
Waialua......	17	K(2),2RC33x78,12RM34x78......	24	2 1/2	12	650	72	2 3/8	1 1/4	650
Pioneer.......	10	K,2RC34x72,S72,15RM34x72.....	27	2 1/4	16	690	..	....	....	....
Maui Agr.....	21	K(2),3RC34x66,18RM34x66......	72	7/8	10	450	72	7/8	7/8	520
Olaa..........	36	K,S72,12RM34x78..............	36	4	4 1/2	475	..	....	....	....
Haw. Sug.....	16	K,2RC28x72,S72,12RM34x78.....	32	4	15	400	..	....	....	....
Onomea.......	34	2RC28x60,S54,12RM32x66.......	..	.....	....	....	..	....	....	....
Honolulu......	13	K(2),S54,2RC32x78,9RM34x78...	24	6	18	380	24	6	4	420
Hakalau......	7	2RC24x54,12RM9-32x60,3-32x66..	..	.....	....	....	..	....	....	....
Kekaha.......	25	2RC24x54,9RM32x60...........	..	.....	....	....	..	....	....	....
Lihue.........	27	K,2RC34x78,S72,12RM34x78.....	10	7	10	350	..	....	....	....
Haw. Agr.....	30	3RC32x60,12RM32x66...........	..	.....	....	....	..	....	...	....
Hilo..........	33	K,2RC24x60,12RM32x66........	10	6	10	200	.	....	....	....
McBryde......	12	2RC34x72,S72,9RM34x84........	..	.....	....	....	..	....	....	....
Wailuku......	2	K,2RC28x72,12RM34x78.........	10	6	18	400	..	....	....	....
Makee........	14	K,2RC34x72,S72,9RM34x72......	12	6	30	420	..	....	....	....
Laupahoehoe..	41	K,2RC30x60,9RM32x60..........	16	3 1/2	2 1/2	540	..	....	....	....
Honokaa......	35	K(2),2RC30x66,12RM32x66......	64	1 1/2	21	440	108	17/32	9	540
Pepeekeo......	19	2RC24x54,9RM32x60............	..	.....	....	....	..	....	....	....
Kahuku.......	43	3RC26x60,S54,9RM34x72........	..	.....	....	....	..	....	....	....
Hamakua.....	15	K,2RC30x60,12RM32x60.........	48	4	1 1/2	400	..	....	....	....
Honomu.......	37	2RC30x60,9RM32x60............	..	.....	....	....	..	....	....	....
Koloa.........	38	K,2RC27x60,12RM32x66.........	24	4 1/2	9	300	..	....	....	....
Paauhau......	24	2RC26x60,12RM32x66...........	..	.....	....	....	..	....	....	....
Waiakea......	3	K,S42,2RC28x60,9RM32x60......	38	6	2	425	..	....	....	....
Hutchinson....	31	2RC30x60,9RM32x60............	..	.....	....	....	..	....	....	....
Hawi.........	26	K(2),2RC28x54,12RM30x54......	8	7	6	380	11	4 4/5	2	408
Waianae......	9	K(2),12RM9-30x60,3-32x60......	12	4 1/2	10	500	42	2 1/2	1	500
Kaiwiki.......	32	K,2RC24x60,9RM32x60..........	18	3	2	300	..	....	....	....
Kohala........	40	K(2),3RC30x60,9RM32x60.......	12	4	18	375	38	1 1/2	1	400
Kilauea.......	23	K,S,3RC31x60,9RM32x60........	10	6	2	250	..	....	....	....
Kaeleku.......	47	K,2RC24x54,9RM32x60.........	9	5 1/2	8	250	..	....	....	....
Waimanalo....	1	K,3RC32x54,9RM30x54.........	28	1 7/8	8	475	..	....	....	....
Halawa.......	29	K,2RC30x60,6RM26x50.........	20	5	1 1/2	375	..	....	....	....
Niulii.........	39	K,9RM30x54......	9	6	6	500	..	....	....	....
Waimea.......	4	2RC24x48,12RM26x42..........	..	.....	....	....	..	....	....	....
Union Mill....	11	K,9RM30x60..................	16	3 3/4	5	200	..	....	....	....
Olowalu.......	18	K,3RC28x48,9RM27x48.........	16	4	1 1/2	400	..	....	....	....

Factory No.	Mill Openings: Crusher	1st Mill Front	1st Mill Back	2nd Mill Front	2nd Mill Back	3rd Mill Front	3rd Mill Back	4th Mill Front	4th Mill Back	5th Mill Front	5th Mill Back
6	1/16	3/8	1/16	1/4	0	1/4	0	3/8	0	...	..
6	1/16	3/8	1/16	1/4	0	1/4	0	3/8	0	...	..
20	1/8	3/8	1/16	1 1/4	0	1/2	0	7/16	0	...	..
20	1/4	3/8	0	1 1/4	0	1/2	0	1/2	0	...	..
5	3/8	1	3/16	3/4	1/16	3/4	0	1/2	3/16	5/8	1/8†
17	5/8	7/16	0	1/16	0	3/16	0	1/8	0	...	..
10	1/16	3/8	1/16	3/8	0	3/8	0	3/8	0	3/8	0
21	7/16x1/16	13/16	0	9/16	0	1/2	0	5/8	3/16	1/2	0‡
36	....	7/8	3/16	9/16	1/8	3/8	0	1/4	0	...	..
16	1/4	7/16	1/16	3/8	0	5/16	0	1/4	0	...	..
34	0	7/16	1/16	3/8	0	1/4	0	1/4	0	...	..
13	1/4	11/16	1/2	3/8	0	5/16	0	...	...	...	..
7	1/8	3/4	0	3/16	0	1/8	0	1/4	0	...	..
25	1/2	3/4	1/4	7/16	1/16	3/8	0	...	...	...	..
27	1/16	7/16	1/16	7/16	0	3/8	0	3/8	0	...	..
30	1 3/4x1/4	3/8	1/8	1/2	1/16	1/2	1/16	1/4	1/16	...	..
33	3/8	5/8	0	1/4	0	1/4	0	1/4	0	...	..
12	1/4	7/16	0	3/8	0	1/4	0	...	...	...	..
2	1/16	3/16	0	5/16	0	1/4	0	3/16	0	...	..
14	0	7/16	0	3/8	0	3/8	0	...	...	...	..
41	3/8	3/8	0	5/16	0	1/4	0	...	...	...	..
35	1/2	5/8	1/8	7/16	1/8	5/16	1/8	1/4	1/32	...	..
19	0	1/2	0	3/32	0	3/32	0	...	...	...	..
43	5x3/8	1/2	1/8	1/4	0	1/8	0	...	...	...	..
15	1/4	1/2	0	3/8	0	1/4	0	3/16	0	...	..
37	3/8	9/16	0	1/4	0	3/16	0	...	...	...	..
38	1/8	3/4	1/16	1/2	1/32	7/16	0	3/8	0	...	..
24	0	1/2	0	1/4	0	3/16	0	3/16	0	...	..
3	3/8	1/2	0	5/16	0	1/4	0	...	...	...	..
31	7/16	3/8	0	1/4	0	3/16	0	...	...	...	..
26	1/2	1/2	1/8	5/16	0	1/4	0	3/16	0	...	..
9	....	11/16	0	3/8	0	5/16	0	1/4	0	...	..
32	3/16	5/16	0	1/4	0	3/16	0	...	...	...	..
40	3/4x3/8	3/8	0	1/4	0	1/8	0	...	...	...	..
23	3/8x1/8	1/8	0	3/16	0	1/8	0	...	...	...	..
47	0	3/4	0	1/4	0	1/8	0	...	...	...	..
1	3/4x1/8	5/16	0	1/4	0	1/4	0	...	...	...	..
29	3/8	5/16	0	1/8	0	...	..	...	...	...	..
39	....	3/8	1/8	1/4	1/8	1/4	0	...	...	...	..
4	0	1/4	1/16	1/2	0	3/8	0	1/4	0	...	..
11	....	1/2	3/16	3/16	0	1/8	0	...	...	...	..
18	3/8x1/8	3/8	0	5/16	0	1/4	0	...	...	...	..

RETURNER BAR

Factory No.	Distance from Top Roller—Inches: Crusher Toe	Crusher Center	Crusher Heel	1st Mill Toe	1st Mill Center	1st Mill Heel	2nd Mill Toe	2nd Mill Center	2nd Mill Heel
6	....	....	....	1 1/2	1 7/8	2 1/8	1 3/8	1 5/8	1 7/8
6	....	....	....	1 1/2	1 7/8	2 1/8	1 3/8	1 5/8	1 7/8
20	....	....	....	1 5/16	1 7/16	1 9/16	1 5/16	1 1/2	1 11/16
20	....	....	....	1 5/16	1 7/16	1 9/16	1 5/16	1 9/16	1 13/16
5	....	....	....	1 1/2	1 3/4	2	1 1/2	1 3/4	2
17	....	....	....	7/8	7/8	1 3/8	3/4	1	1 1/2
10	....	....	....	1 3/8	1 5/8	1 3/4	1 1/4	1 1/2	1 5/8
21	....	1 1/2	....	.....	1 1/2	....	.....	1 1/2	....
36	....	....	....	1 1/4	1 3/8	1 7/8	1	1 1/8	1 5/8
16	....	....	....	1 1/4	1 1/2	1 3/4	1 1/4	1 1/2	1 3/4
34	....	....	....	1 1/4	1 3/8	1 1/2	1 1/4	1 3/8	1 1/2
13	....	....	....	1 3/8	1 1/2	1 5/8	1 1/4	1 1/2	1 3/4
7	..	....	....	1	1 1/4	2	7/16	1	1 15/16
25	....	....	....	.....	2 1/2	....	.....	2	....
27	....	....	....	7/8	1 3/8	1 3/4	1 1/8	1 1/2	2
30	1 5/8	1 3/4	1 7/8	1 1/4	1 3/8	1 1/2	1 1/8	1 1/4	1 3/8
33	....	....	....	1 1/8	1 3/8	1 5/8	1 1/16	1 5/16	1 1/2
12	....	....	....	1 1/2	1 3/4	2	1 5/8	1 7/8	2 1/4
2	....	....	....	1 1/4	1 1/2	1 3/4	1 3/8	1 5/8	1 7/8
14	....	....	....	1	1 1/2	2	1	1 1/2	2
41	....	....	....	3/4	1 3/8	1 3/4	5/8	1	1 1/2
35	....	....	....	1 3/16	1 1/4	1 1/2	1 3/16	1 1/2	2
19	....	....	....	1	1 1/8	1 1/4	3/4	1 1/16	1 7/8
43	....	....	....	3/4	1	1 3/4	3/8	1	1 1/2
15	....	....	....	1 1/4	1 1/2	1 3/4	1 1/4	1 1/2	1 3/4
37	....	....	....	3/8	1	1 1/8	3/8	7/8	1 1/8
38	....	....	....	1 1/2	1 3/4	2	1 1/4	1 1/2	1 3/4
24	....	....	....	1	1 5/8	2 3/8	1	1 1/2	2 1/4
3	....	....	....	1 3/16	1 1/4	1 5/8	1 1/16	1 3/16	1 9/16
31	....	....	....	1 1/8	1 1/2	1 7/8	5/8	7/8	1 1/4
26	....	....	....	1 1/8	1 3/8	1 5/8	1	1 1/4	1 1/2
9	....	....	....	1 1/4	1 1/2	1 7/8	1 1/16	1 1/4	1 5/8
32	....	....	....	1 3/4	1 1/2	2 5/16	3/4	1	1 5/8
40	1 1/2	1 3/4	2 1/4	3/8	1 1/8	1 5/8	1/2	1 1/8	1 3/4
23	1 7/16	1 1/2	1 5/8	1 1/16	1 3/8	2 5/16	1 3/8	1 13/16	2 3/8
47	....	....	....	1 1/4	1 1/2	1 3/4	1	1 1/4	1 1/2
1	1/2	5/8	7/8	1	1 1/4	1 7/16	1	1 1/4	1 7/16
29	....	....	....	5/8	1	1 1/2	5/8	13/16	1 1/8
39	....	....	....	1 1/8	1 3/8	1 1/2	1	1 1/8	1 1/4
4	....	....	....	1 1/8	1 1/2	1 3/4	1	1 3/8	1 5/8
11	....	....	....	7/8	1	1 1/2	1 3/16	1 1/4	1 1/2
18	3/8	1/2	7/8	11/16	7/8	1 3/16	7/8	1	1 1/4

Factory No.	3rd Mill Toe	3rd Mill Center	3rd Mill Heel	4th Mill Toe	4th Mill Center	4th Mill Heel	5th Mill Toe	5th Mill Center	5th Mill Heel
6	1 3/8	1 5/8	1 7/8	1 3/8	1 5/8	1 7/8	....	....	....
6	1 3/8	1 5/8	1 7/8	1 3/8	1 5/8	1 7/8	....	....	....
20	9/16	11/16	3/4	1 3/16	1 1/4	1 3/8	....	....	....
20	1 3/8	1 1/2	1 11/16	1 3/8	1 1/2	1 11/16	....	....	....
5	1 1/2	1 5/8	1 3/4	1 5/8	1 3/4	2	1 1/2	1 3/4	2
17	1/2	5/8	1 1/4	3/8	3/4	1 1/2	....	....	....
10	1 1/4	1 1/2	1 5/8	1 1/4	1 1/2	1 5/8	1 1/4	1 1/2	1 5/8
21	.....	1 5/8	....	.....	1 1/2	....	.....	1 1/2	....
36	1	1 1/8	1 1/2	7/8	1	1 3/8	....	....	....
16	1 1/4	1 1/2	1 3/4	1	1 1/4	1 1/2	....	....	....
34	1 1/8	1 3/8	1 5/8	1 1/8	1 3/8	1 5/8	....	....	....
13	1 3/8	1 1/2	1 3/4	.....	.....	....	....	....	....
7	3/8	1	2	11/16	1	2	....	....	....
25	.....	1 1/2	....	.....	.....	....	....	....	....
27	1	1 1/2	2	1	1 3/8	2	....	....	....
30	1 1/8	1 1/4	1 3/8	3/4	7/8	1	....	....	....
33	1 1/16	1 5/16	1 1/2	1	1 3/16	1 1/2	....	....	....
12	1 3/8	1 1/2	2	.....	.....	....	....	....	....
2	1 1/4	1 1/2	1 3/4	1 3/8	1 5/8	1 7/8	....	....	....
14	1	1 1/2	2	.....	.....	....	....	....	....
41	3/8	7/8	1 1/2	.....	.....	....	....	....	....
35	9/16	1 1/16	1 5/8	1 1/16	1 7/16	1 7/8	....	....	....
19	1 5/16	1 1/8	2 1/8	.....	.....	....	....	....	....
43	1/2	3/4	1 3/8	.....	.....	....	....	....	....
15	1 1/8	1 3/8	1 5/8	1	1 1/4	1 1/2	....	....	....
37	3/8	3/4	1	.....	.....	....	....	....	....
38	1 1/4	1 1/2	1 3/4	1 1/4	1 1/2	1 3/4	....	....	....
24	1 1/2	1 1/2	2	1 7/16	1 9/16	2	....	....	....
3	3/4	15/16	1 1/4	.....	.....	....	....	....	....
31	3/4	1	1 1/4	.....	.....	....	....	....	....
26	7/8	1 1/8	1 3/8	3/4	1	1 1/8	....	....	....
9	7/8	1 1/8	1 1/2	3/4	1	1 1/2	....	....	....
32	1/2	3/4	1 1/4	.....	.....	....	....	....	....
40	3/8	1	1 3/8	.....	.....	....	....	....	....
23	1	1 3/8	1 13/16	.....	.....	....	....	....	....
47	3/4	1	1 1/4	.....	.....	....	....	....	....
1	1	1 1/4	1 7/16	.....	.....	....	....	....	....
29	.....	.....	....	.....	.....	....	....	....	....
39	1	1 1/8	1 1/4	.....	.....	....	....	....	....
4	7/8	1 1/8	1 1/2	3/4	1 1/16	1 7/16	....	....	....
11	1 1/8	1 1/16	1 3/8	.....	.....	....	....	....	....
18	5/8	1	1 1/4	.....	.....	....	....	....	....

Factory No.	Width—Inches: 1st Mill	2nd Mill	3rd Mill	4th Mill	5th Mill	6th Mill	Distance from Back Roller—Inches: 1st Mill	2nd Mill	3rd Mill	4th Mill	5th Mill	6th Mill
6	13	12 1/2	12	12 1/4	......	......	1/2	1/2	1/2	1/2	...	...
6	13	12 1/2	12	12 1/4	......	......	1/2	1/2	1/2	1/2	...	...
20	11 3/4	13 1/2	13 1/2	11 1/2	......	......	1	1/2	1 5/8	1 1/4	...	...
20	14	15	12	13	......	......	1	1 1/8	1 1/16	1/2	...	...
5	12 1/2	13	13	12 1/2	13	13	1/2	1/4	3/8	1/4	1/8	1/4
17	15 1/2	14 1/4	14 1/4	14 1/4	......	......	1	1 1/4	1 3/4	3/4	...	...
10	12 3/4	12	12 3/8	12 3/4	12 3/4	......	5/8	9/16	9/16	5/8	9/16	...
21	12	12	12	12	12	12	15/16	3/4	1/2	3/4	1/2	1/2
36	13	13	13	12	......	......	3/4	1/2	1/2	1/2	...	...
16	14	14	14	14	......	......	1/2	3/8	3/8	1/4	...	...
34	12	12 1/4	12 1/4	12 1/4	......	......	1/2	1/2	1/2	1/2	...	...
13	13	13	11 3/4	......	......	......	1/2	9/16	1/2	...	...	...
7	11 3/4	12 1/4	12	12 1/4	......	......	7/16	9/16	1/2	1/2	...	...
25	12	11 1/2	11 1/2	......	......	......	1/2	3/8	3/8	...	...	...
27	13 3/8	14 1/2	14	12 1/2	......	......	3/8	1/2	3/8	3/8	...	...
30	13 1/2	13	12 3/4	12 1/2	......	......	1/2	1/2	1/2	3/8	...	...
33	11 1/2	11 1/2	11 1/2	11	......	......	3/8	1/4	1/4	5/16	...	...
12	12 1/4	13	13	......	......	......	7/8	3/4	1/2	...	...	...
2	11	11 3/4	14	13 7/8	......	......	3/4	1/2	9/16	1/2	...	...
14	13	13	13	......	......	......	1/4	1/4	1/8	...	...	...
41	10 1/4	10 1/2	10 1/2	......	......	......	5/8	5/8	5/8	...	...	...
35	10 1/2	10 1/2	12	12	......	......	5/8	1	7/8	3/4	...	...
19	14 1/2	13 1/2	12 1/8	......	......	......	1/2	1/2	1/2	...	...	...
43	14	15	12 1/4	......	......	......	1/4	1/4	1/4	...	...	...
15	12 1/2	12 1/2	12 1/4	11 1/2	......	......	1/2	1/2	1/2	1/2	...	...
37	11 7/8	12	12	......	......	......	7/8	3/4	3/4	...	...	...
38	12	11	9 1/2	9 1/2	......	......	1/4	3/8	3/8	3/8	...	...
24	12 1/4	12 1/2	11 5/8	10	......	......	1/4	1	1/2	3/4	...	...
3	12 1/2	12 1/4	13 1/2	......	......	......	1/4	1/4	1/4	...	...	...
31	13	13	11 1/2	......	......	......	1/2	1/2	1/2	...	...	...
26	11 1/2	11 1/2	11 1/2	11 1/2	......	......	3/4	3/4	3/4	3/4	...	...
9	13	12 1/2	11 1/2	12	......	......	1/4	3/16	1/4	1/4	...	...
32	11 1/4	13	13	......	......	......	1/2	1/2	1/2	...	...	...
40	12 1/2	12 1/4	9 1/4	......	......	......	1/2	1/4	1/2	...	...	...
23	12 3/8	11 3/4	12 1/2	......	......	......	1/2	3/8	1/8	...	...	...
47	12 3/4	12 1/4	12 3/4	......	......	......	1/2	1/2	1/2	...	...	...
1	11 1/4	11 1/4	11 1/4	......	......	......	1/2	1/2	1/2	...	...	...
29	11	11	......	......	......	......	5/16	3/8	...	...	...	...
39	......	......	......	......	......	......	7/8	3/4	1	...	...	...
4	9	11	10	10	......	......	7/8	1/2	3/4	3/4	...	...
11	13	12	13	......	......	......	3/16	5/8	3/4	...	...	...
18	11	11	11	......	......	......	5/8	5/8	3/8	...	...	...

Factory No.	Speed of Rollers—Feet per Minute: Crusher	1st Mill	2nd Mill	3rd Mill	4th Mill	5th Mill	6th Mill	Pressure on Rollers—Tons: Crusher	1st Mill	2nd Mill	3rd Mill	4th Mill	5th Mill	6th Mill	Tons Cane per Hour	Tonnage Ratio	Factory No.	Factory
6	38	24	26.5	29	32	....	....	300	400	420	450	525	....	....	52.51*	1.49	6	H. C. & S. Co.
6	38	24	26.5	29	30	....	....	300	400	420	450	525	....	....			6	" "
20	27.9	24.1	18.2	20.9	21.4	....	....	178	454	414	415	414	....	....	51.16*	1.43	20	Oahu
20	27.9	23.2	17.6	20	20.7	....	....	246	368	358	407	381	....	....			20	"
5	16.4	16.3	18.5	19.9	23.3	26.7	30.1	340	380	380	410	280	320	440	68.84	1.40	5	Ewa
17	24.4	22.9	17.6	20	21.4	....	....	290	440	420	420	440	....	....	54.21	1.54	17	Waialua
10	48.2	28.2	29.3	23.9	27.3	31.4	....	230	417	423	357	348	358	....	75.0	2.08	10	Pioneer
21	23	23.5	25.2	28.8	23.5	25.2	28.8	450	340	350	486	260	230	380	60.07	1.70	21	Maui Agr.
36	....	23.3	23.8	27.3	31.4	....	....	....	420	420	420	450	....	....	54.72	1.94	36	Olaa
16	23	14	16	16.7	18	....	....	260	350	416	490	516	....	....	40.54	1.15	16	Haw. Sug.
34	29.1	19.7	22.1	20.8	21.5	....	....	....	400	400	400	400	....	....	39.50	1.57	34	Onomea
13	17.4	16.6	18.7	20.4	....	....	....	250	450	450	450	....	....	....	36.9	1.31	13	Honolulu
7	30.5	21.6	24.2	26.5	15.8	....	....	....	322	322	345	380	....	....	31.52	1.51	7	Hakalau
25	17	14.3	16	17.3	....	....	....	....	368	390	399	....	....	....	29.38	1.76	25	Kekaha
27	28.2	17.6	17.1	17.1	18.8	....	....	290	470	410	430	460	....	....	54.71	1.55	27	Lihue
30	21.5	19.3	20.2	22.3	24	....	....	350	383	383	402	500	....	....	46.18	1.83	30	Haw. Agr.
33	28	20	22	23.5	14.2	....	....	....	395	395	395	430	....	....	39.46	1.57	33	Hilo
12	26	18	18	18	....	....	....	250	400	380	525	....	....	....	36.88	1.13	12	McBryde
2	30.3	19.1	15.3	16.9	19.3	....	....	....	400	360	350	350	....	....	38.43	1.09	2	Wailuku
14	25.9	22.5	25.7	29.5	....	....	....	250	450	475	475	....	....	....	52.51	2.19	14	Makee
41	....	....	....	....	....	....	....	250	374	374	374	....	....	....	27.49	1.67	41	Laupahoehoe
35	27.7	19.8	18.2	22.1	24.4	....	....	173	352	332	325	365	....	....	39.82	1.58	35	Honokaa
19	31.4	17.9	19.7	21.6	....	....	....	....	380	380	380	....	....	....	25.95	1.56	19	Pepeekeo
43	16.1	9.9	11.2	13	....	....	....	192	434	398	499	....	....	....	23.16	0.97	43	Kahuku
15	25	15.7	18.1	20.2	21.8	....	..	....	360	316	333	370	....	....	27.15	1.30	15	Hamakua
37	21.2	18.3	21	23.3	....	....	....	....	318	318	318	....	....	....	25.07	1.50	37	Honomu
38	22.1	17	18.7	17	18.7	....	....	140	400	380	400	400	....	....	30.75	1.22	38	Koloa
24	27.7	16.1	17.8	19.7	21.7	....	....	....	406	319	372	401	....	....	31.16	1.24	24	Paauhau
3	23.3	14.9	16.7	19.7	....	....	....	173	297	282	289	....	....	....	25.22	1.51	3	Waiakea
31	22.1	18	19.9	22	....	....	....	....	404	398	414	....	....	....	26.66	1.60	31	Hutchinson
26	30	22	18.8	19	21.5	....	....	135	292	349	311	359	....	....	23.10	1.37	26	Hawi
9	....	16.9	16.9	16.9	18.9	....	....	....	288	290	293	347	....	....	24.35	1.46	9	Waianae
32	20.1	17	19.4	21.3	....	....	....	....	387	319	320	....	....	....	25.47	1.53	32	Kaiwiki
40	25	18	20	25	....	....	....	....	304	375	380	....	....	....	25.86	1.55	40	Kohala
23	18	19.5	20.5	20.5	....	....	....	300	320	310	312	....	....	....	24.75	1.48	23	Kilauea
47	21.4	17.7	19.5	22	....	....	....	....	329	346	304	....	....	....	24.96	1.50	47	Kaeleku
1	18.4	18.1	21.5	21.5	....	....	....	340	300	300	300	....	....	....	18.30	1.36	1	Waimanalo
29	12.8	16	11.8	....	....	....	....	179	180	220	....	....	....	....	13.81	1.59	29	Halawa
39	....	19.9	18.1	18.1	....	....	....	....	185	185	203	....	....	....	15.24	1.50	39	Niulii
4	19.6	13.6	14.1	13.6	17	....	....	....	215	....	154	154	....	....	13.29	1.30	4	Waimea
11	....	15.2	13.6	13.4	....	...	....	....	315	278	298	....	....	....	18.33	1.47	11	Union Mill
18	17.8	18.5	30.8	30.8	....	....	....	202	202	220	220	....	....	....	17.10	1.60	18	Olowalu

*Tons of cane per hour for one tandem.
†6th Mill. Openings 1/4x0, returner bar from top roller, 1 1/2, 1 5/8, 1 3/4.
‡6th Mill. Openi[illegible] 1/16x0, returner bar from top roller, center 1 3/8.

ANNUAL SYNOPSIS OF MILL DATA—SHOWING RESULTS FROM 39 HAWAIIAN FACTORIES FOR CROP OF 1923

Factory	Factory No.	Milling Plant (Sizes in Inches)	Cane: Polarization	Cane: % Fiber	Cane: Tons per ton commercial sugar	Cane: Tons ground per hour	Cane: Tonnage ratio	Bagasse: Polarization	Bagasse: % Moisture	Bagasse: % Fiber	Bagasse: Pol. per 100 cane	Bagasse: Pol. per 100 pol. of cane	Bagasse: Pol. per 100 Fiber "Milling Loss"	Bagasse: Weight per 100 cane
H. C. & S. Co.**	6	K(4),2RC78(2),S72(2),12RM78(2)	12.98	11.95	7.55	32.511	1.49	1.95	42.14	55.08	0.42	3.02	3.54	21.68
Oahu	20	K(2),2RC78(2),S72(2),12RM78(2)	13.69	12.35	7.89	51.161	1.45	1.36	40.91	57.04	0.29	2.15	2.38	21.63
Ewa††	5	K(2),2RC78,18RM78	12.39	12.07	8.85	68.84	1.40	1.50	43.43	54.24	0.36	2.90	2.77	23.91
Waialua††	17	K(2),2RC78,12RM78	13.07	12.73	8.48	54.21	1.54	1.54	43.11	54.63	0.36	2.75	2.82	23.32
Pioneer	10	K(2),2RC72,S72,15RM72	13.73	11.77	7.84	75.00	2.08	1.34	43.23	54.85	0.29	2.10	2.45	21.45
Maui Agr.**	21	K(2),2RC66,15RM66	13.45	11.76	7.63	60.07	1.70	1.41	46.88	50.78	0.33	2.44	2.78	23.16
Olaa	36	K,S72,12RM78	12.33	12.97	9.00	54.72	1.94	1.73	44.28	53.17	0.42	3.40	3.25	24.24
Haw. Sug.	16	K,2RC78,S72,12RM78	14.27	12.30	7.51	40.54	1.15	1.48	41.78	56.18	0.32	2.27	2.63	21.88
Onomea	34	2RC60,S54,12RM66	12.41	14.70	8.54	39.50	1.57	0.66	38.04	60.98	0.14	1.12	1.09	20.97
Honolulu	13	K(2),S54,2RC78,9RM78	13.45	12.22	8.89	36.9	1.31	2.14	39.96	56.86	0.46	3.41	3.76	21.50
Hakalau	7	2RC54,12RM9-60,2-60	12.45	12.88	8.41	31.52	1.51	0.68	36.57	62.44	0.14	1.13	1.09	20.62
Kekaha	25	2RC54,9RM78	13.68	11.95	8.12	29.38	1.76	2.30	40.51	56.11	0.49	3.58	4.10	21.29
Lihue	27	K,2RC78,S72,12RM78	12.32	12.88	8.76	54.71	1.55	1.25	41.25	56.82	0.28	2.31	2.20	22.67
Haw. Agr.†‡	30	3RC60,12RM66	11.82	13.37	9.49	46.18	1.83	1.51	39.76	58.28	0.35	2.93	2.59	22.94
Hilo	33	K,2RC60,12RM66	12.02	13.78	8.80	39.46	1.57	0.73	39.17	59.76	0.17	1.40	1.22	23.06
McBryde	12	2RC72,S72,9RM84	12.90	11.95	8.63	36.88	1.13	1.82	41.32	56.09	0.45	3.52	3.24	24.89
Wailuku	2	K,2RC72,12RM78	13.06	12.51	8.26	38.43	1.09	1.48	39.73	58.00	0.32	2.45	2.55	21.56
Makee	14	K,2RC72,S72,9RM72	12.03	14.09	9.34	52.51	2.19	1.27	41.88	56.35	0.32	2.64	2.25	24.88
Laupahoehoe	41	2RC60,9RM60	12.07	12.92	8.77	27.49	1.65	1.76	38.35	59.27	0.38	3.05	2.97	21.83
Honokaa	35	K(2),2RC66,12RM66	11.25	12.65	9.88	39.82	1.58	1.84	43.61	53.83	0.43	3.84	3.42	23.50
Pepeekeo	19	2RC54,9RM60	12.37	12.81	8.66	25.95	1.56	1.14	38.94	59.52	0.24	1.98	1.92	21.52
Kahuku††	43	3RC60,S54,9RM78	11.62	15.73	9.72	23.36	0.97	1.63	40.87	56.59	0.45	3.91	2.88	27.84
Hamakua	15	K,2RC60,12RM60	12.23	14.15	9.18	27.35	1.30	1.16	42.34	56.07	0.29	2.38	2.07	25.21
Honomu	37	2RC60,9RM60	12.53	12.84	8.71	25.07	1.50	1.60	37.87	59.90	0.33	2.65	2.67	20.43
Koloa	38	K,2RC60,12RM60	12.29	13.88	9.38	30.75	1.22	1.54	42.02	55.43	0.39	3.14	2.78	25.04
Paauhau	24	2RC60,12RM66	11.47	13.53	9.55	31.16	1.24	1.37	38.59	59.42	0.31	2.72	2.31	22.78
Waiakea	3	K,S42,2RC60,9RM60	12.56	14.84	8.05	25.22	1.21	2.02	42.34	54.84	0.50	4.00	3.68	24.72
Hutchinson†‡	31	3RC60,9RM60	10.92	12.91	10.31	26.66	1.50	1.65	41.55	55.85	0.38	3.50	2.95	23.12
Hawi	26	K(2),2RC54,12RM54	13.72	14.20	8.60	23.10	1.27	2.63	41.15	55.23	0.58	4.23	4.76	22.08
Waianae	9	K,2RC54,12RM60	13.06	12.70	8.71	24.35	1.46	1.92	41.00	56.25	0.43	3.32	3.41	22.58
Kaiwiki††	32	K,2RC60,9RM60	11.96	12.99	9.33	25.47	1.53	2.01	40.13	57.12	0.46	3.81	3.52	22.69
Kohala	40	K(2),2RC60,9RM60	12.11	13.23	9.16	25.86	1.55	1.99	43.56	53.66	0.49	4.05	3.71	24.65
Kilauea††	23	K,S,3RC60,9RM60	12.37	13.44	10.01	24.75	1.48	1.42	40.00	57.89	0.33	2.89	2.47	23.10
Kaeleku	47	K,2RC54,9RM60	11.72	14.23	9.90	24.96	1.50	2.39	40.49	56.34	0.60	5.14	4.24	25.25
Halawa	29	K,2RC60,6RM50	11.55	14.19	10.58	18.80	1.59	3.13	42.17	53.84	0.83	7.14	5.81	26.36
Niulii	39	K,S,RM54	11.56	14.78	10.20	15.24	1.50	3.09	47.85	48.09	0.95	8.21	6.43	30.73
Waimea	4	2RC48,12RM42	12.73	11.79	8.53	13.29	1.30	1.55	38.27	59.33	0.31	2.43	2.60	19.77
Union Mill††	11	2RC54,9RM54	11.51	14.54	10.1	18.33	1.47	2.83	43.67	52.27	0.79	6.84	5.41	27.82
Olowalu	18	K,2RC48,9RM48	13.08	11.68	9.08	17.10	1.50	1.18	38.67	59.56	0.23	1.76	1.98	19.56
True Average, 1923	1923		12.78	12.88	8.56			1.55	41.56	56.18	0.35	2.77	2.76	22.80
" " 1922	1922		12.97	12.95	8.62			1.69	41.51	56.05	0.39	3.02	3.02	23.09
" " 1921	1921		13.12	12.80	8.61			1.50	41.20	56.58	0.34	2.57	2.64	22.58
" " 1920	1920		13.64	12.64	8.12			1.56	41.05	56.68	0.35	2.55	2.75	22.29
" " 1919	1919		13.74	12.40	7.94			1.67	41.57	56.05	0.37	2.70	2.97	22.27
" " 1918	1918		12.97	12.50	8.51			1.59	42.70	55.04	0.36	2.79	2.90	22.74
" " 1917	1917		12.78	12.62	8.03			1.78	42.26	55.31	0.41	2.95	3.22	22.83
" " 1916	1916		13.45	12.74	8.16			1.81	42.49	54.98	0.42	3.13	3.30	23.19
" " 1915	1915		13.77	12.51	7.98			2.17	43.87	53.07	0.51	3.72	4.09	23.57
" " 1914	1914		13.78	12.74	8.13			2.49	45.72	50.87	0.62	4.52	4.89	25.04

Factory No.	First Expressed Juice: Brix	F.E.J.: Polarization	F.E.J.: Purity	F.E.J.: Pol. of cane x 100 / Polarization	Mixed Juice: Brix	M.J.: Polarization	M.J.: Purity	M.J.: Weight per 100 cane	M.J.: Pol. per 100 cane	M.J.: Pol. per 100 pol. of cane "Extraction"	M.J.: Extraction Ratio	Last Expressed Juice: Polarization	L.E.J.: Purity	Maceration Water: Weight per 100 cane	Maceration Water: Dilution % normal juice
6	19.38	17.30	89.28	80.8	13.75	12.06	87.68	112.36	13.56	96.98	0.25	2.58	70.14	34.04	38.11
20	19.17	16.61	86.65	81.6	13.47	11.45*	85.00	116.95	13.40	97.85	0.17	0.95	66.20	38.58	37.05
5	18.68	15.84	84.77	78.2	13.30	10.82	81.35	111.17	12.03	97.10	0.22	1.10	64.50	35.08	32.41
17	18.57	16.16	87.0	80.9	13.05	10.86	83.2	117.09	12.71	97.25	0.22	2.25	68.0	40.41	38.70
10	19.60	17.27	88.11	79.5	15.22	12.96	85.14	103.70	13.44	97.90	0.18	0.84	70.05	25.15	26.32
21	17.99	15.84	88.05	84.9	12.16	10.54*	86.68	124.53	13.12	97.56	0.21	1.54	60.87	47.69	47.94
36	16.96	14.75	87.0	83.6	12.94	10.87	84.0	109.54	11.91	96.60	0.26	0.95	66.4	33.78	31.1
16	19.23	16.86	87.68	84.6	13.38	11.41	85.28	122.15	13.94	97.73	0.18	1.72	72.57	44.04	43.05
34	16.49	14.59	88.48	85.1	12.17	10.42	85.63	117.72	12.27	98.88	0.09	1.36	67.66	38.70	36.85
13	19.21	16.36	85.2	82.2	13.13	10.80	82.25	120.33	12.99	96.59	0.28	1.36	67.4	41.83	42.7
7	16.79	14.73	87.73	84.5	11.42	9.74	85.29	126.42	12.31	98.87	0.09	1.23	69.10	47.05	47.02
25	18.55	16.65	89.76	82.2	13.85	11.94	86.21	110.50	13.19	96.42	0.30	1.94	72.66	31.79	31.05
27	18.51	15.79	85.3	78.0	13.43	11.06	82.4	108.76	12.03	97.69	0.18	1.72	64.7	31.43	31.43
30	16.71	14.80	88.57	79.9	13.73	11.93	86.89	96.23	11.48	97.07	0.22	2.48	76.07	19.17	14.71
33	16.06	13.89	86.49	86.5	11.86	9.99	84.23	118.63	11.85	98.60	0.10	1.63	68.48	41.68	39.63
12	18.72	16.37	87.45	78.8	12.67	10.60	83.66	117.42	12.44	96.48	0.25	2.28	70.37	42.31	42.23
2	18.67	16.70	89.4	78.1	13.78	11.74	85.2	108.46	12.73	97.55	0.20	1.43	65.0	30.02	27.87
14	18.07	15.35	84.95	78.4	13.60	11.21	82.43	104.46	11.71	97.36	0.19	3.66	68.80	29.34	25.37
41	16.82	14.92	88.70	84.2	12.24	10.44	85.29	116.72	12.19	96.95	0.24	2.87	73.97	38.55	38.81
35	16.40	14.26	86.95	78.9	12.19	10.17	83.43	106.41	10.82	96.16	0.30	1.97	71.90	29.91	29.2
19	16.97	14.89	87.7	83.1	13.09	11.09	84.7	109.34	12.13	98.02	0.15	1.98	74.2	30.86	28.34
43	17.71	14.67	82.83	79.2	12.87	10.19	79.17	109.57	11.16	96.09	0.25	1.59	64.11	37.41	33.48
15	18.06	16.05	88.87	76.2	13.29	11.22	84.42	106.39	11.94	97.62	0.17	1.95	72.76	31.61	27.46
37	16.81	14.78	87.9	83.4	12.24	10.27	83.9	116.83	12.00	97.35	0.22	2.25	71.7	37.26	37.34
38	18.61	15.55	83.6	79.0	13.33	10.60	79.5	112.34	11.91	96.86	0.23	0.99	60.3	37.38	35.71
24	16.95	14.89	87.8	77.0	12.50	10.44	83.5	106.89	11.16	97.28	0.20	2.00	69.0	29.67	27.60
3	18.02	15.67	86.96	79.6	13.31	11.25	84.53	106.45	11.98	96.00	0.29	2.83	71.65	31.17	29.15
31	15.38	13.44	87.39	81.3	11.42	9.55	83.63	110.30	10.53	96.50	0.27	1.38	63.59	33.42	32.32
26	18.34	16.30	88.90	84.2	15.20	13.11	86.25	100.23	13.14	95.77	0.35	4.34	73.60	22.31	19.9
9	19.26	16.55	85.93	78.9	13.13	10.73	81.80	117.69	12.63	96.68	0.26	3.26	69.96	40.27	39.73
32	17.77	15.48	87.11	77.3	12.60	10.59	84.05	108.64	11.51	96.19	0.29	2.73	72.99	31.33	30.40
40	16.88	14.63	86.67	82.8	11.95	9.95	83.26	116.78	11.62	95.95	0.31	1.59	71.62	41.43	40.42
23	17.86	15.03	84.2	75.6	12.98	10.39	80.0	106.29	11.04	97.11	0.22	1.85	67.3	29.39	.....
47	16.97	14.50	85.45	80.8	13.05	10.75	82.38	103.41	11.12	94.86	0.36	4.43	75.21	28.66	27.66
29	16.53	14.19	85.84	81.4	13.03	10.93	83.88	98.08	10.72	92.86	0.50	6.46	78.49	24.44	23.71
39	16.41	14.01	85.38	82.5	12.78	10.65	83.36	99.60	10.61	91.79	0.56	4.36	76.10	30.33	28.41
4	17.93	15.23	84.9	83.6	13.57	11.34	83.56	109.52	12.42	97.57	0.21	2.76	69.5	29.29	28.9
11	17.29	14.86	85.94	77.5	12.84	10.58	82.37	101.43	10.73	93.16	0.47	4.84	73.3	27.25	26.96
18	18.49	16.09	87.0	81.3	13.30	11.00	82.7	116.82	12.85	98.24	0.15	2.25	66.8	36.38	35.11
1923	18.09	15.75	87.05	81.1	13.13	11.06	84.27	112.32	12.42	97.23	0.22	1.79	68.31	35.12	.....
1922	18.44	16.01	86.84	81.0	13.46	11.27	83.73	111.48	12.58	96.98	0.23	1.93	69.13	34.75	....
1921	18.74	16.16	86.22	81.2	13.25	10.97	82.77	116.50	12.79	97.43	0.20	1.68	65.89	39.30	....
1920	19.32	16.85	87.24	80.9	13.48	11.31	83.87	117.35	13.29	97.45	0.20	1.65	68.20	39.95	....
1919	19.17	16.74	87.34	82.0	13.39	11.29	84.29	118.29	13.37	97.30	0.22	1.70	68.53	40.80	....
1918	18.26	15.92	87.18	81.3	12.92	10.85	83.99	116.05	12.60	97.21	0.22	1.56	69.52	38.99	....
1917	19.14	16.85	88.02	81.6	13.48	11.45	84.88	116.53	13.34	97.05	0.23	1.71	71.15	39.39	....
1916	18.64	16.34	87.70	82.3	13.17	11.14	84.59	116.99	13.03	96.87	0.25	1.75	71.71	39.85	....
1915	18.87	16.65	88.24	82.7	14.03	11.89	84.75	111.44	13.26	96.30	0.30	1.96	73.88	35.04	....
1914	18.86	16.73	88.71	82.4	14.19	12.16	85.70	108.14	13.15	95.46	0.36	2.28	74.96	33.64	....

Factory No.	Clarified juice purity	Syrup: Brix	Syrup: Purity	Syrup: Increase in Purity	Press Cake: Polarization	P.C.: Weight per 100 cane	P.C.: Pol. per 100 cane	P.C.: Pol. per 100 pol. of cane	Lime Used (Weight per 100 Cane): In Juice	Lime: In Settlings	Lime: Total	Commercial Sugar: Polarization	C.S.: % Moisture	C.S.: Weight per 100 cane	C.S.: Pol. per 100 cane	C.S.: Pol. per 100 pol. of cane	C.S.: Pol. per 100 pol. of juice	C.S.: Total weight in thousand tons
6	87.68	63.07	87.65	...	3.97	0.31	0.01	0.09	...	...	0.10	96.94	0.92	13.24	12.83	91.78	94.63	44
20	85.86	63.62	86.80	1.80*	1.94	1.86	0.04	0.26	0.07	0.02	0.09	97.24*	0.68	12.67	12.32	90.02	92.00	46
5	83.25	66.61	82.96	1.61	1.87	2.38	0.04	0.36	0.07	0.02	0.09	97.04	0.68	11.30	10.97	88.49	91.13	40
17	85.2	64.67	84.60	1.40	2.68	2.80	0.07	0.57	...	...	0.10	96.69	0.75	11.79	11.41	87.26	89.73	28
10	86.36	66.68	86.16	1.02	1.33	3.14	0.04	0.31	...	...	0.06	97.41	0.66	12.76	12.43	90.54	92.49	28
21	86.27	64.38	87.19	...	....	....	....	....	...	...	0.10	97.40*	0.64	12.78	12.45	92.56	94.88	20
36	85.8	65.13	85.8	1.8	3.82	1.59	0.06	0.49	...	...	0.08	97.19	0.92	11.11	10.80	87.61	90.69	26
16	85.92	66.80	86.30	1.02	5.32	2.29	0.12	0.85	0.06	0.01	0.07	96.72	0.68	13.31	12.88	90.25	92.34	22
34	87.17	68.09	87.34	1.71	0.40	2.22	0.01	0.07	...	...	0.07	97.13	0.85	11.71	11.38	91.70	92.74	18
13	85.3	56.54	85.23	2.98¶	0.62	3.19	0.02	0.15	...	...	0.12	....	...	....	....	....	....	15†
7	86.01	66.16	85.87	0.58	0.47	3.29	0.02	0.13	...	...	0.06	96.38	1.01	11.90	11.47	92.08	93.14	14
25	87.30	57.91	87.27	1.06	3.87	2.90	0.11	0.82	0.08	0.02	0.10	96.33	1.01	12.31	11.86	86.67	89.89	16
27	82.8	61.08	83.24	0.84¶	1.73	1.81	0.03	0.25	...	...	0.08	96.70	1.00	11.42	11.04	89.65	91.77	19
30	87.33	56.68	87.61	0.72	4.07	2.22	0.09	0.76	...	...	0.09	97.01	0.77	10.53	10.22	86.43	89.05	19§
33	84.38	66.37	85.91	1.68	1.46	2.23	0.03	0.27	...	...	0.07	96.52	1.02	11.37	10.97	91.29	92.59	18
12	84.49	59.33	85.54	1.88	2.00	1.78	0.04	0.28	0.04	0.02	0.06	96.69	0.94	11.59	11.20	86.88	90.05	12
2	86.3	58.37	87.0	1.8	1.00	2.53	0.02	0.19	...	...	0.17	97.04	0.72	12.11	11.75	89.99	92.25	15
14	83.36	58.00	83.21	0.78	1.32	2.78	0.04	0.30	0.06	0.02	0.08	97.07	0.98	10.71	10.39	86.38	88.72	13
41	86.75	69.43	86.95	1.66	0.98	2.23	0.02	0.17	0.05	0.01	0.06	96.72	1.07	11.40	11.02	87.67	90.43	9
35	84.55	62.42	84.89	1.46	2.19	2.18	0.05	0.42	0.06	0.01	0.07	96.34	0.95	10.12	9.75	86.66	90.12	13
19	85.5	67.78	86.0	1.3	0.72	2.22	0.02	0.13	...	...	0.07	96.98	0.67	11.63	11.28	91.17	93.01	9
43	81.38	63.17	80.78	1.61	4.45	2.39	0.11	0.91	...	...	0.14	96.94	0.93	10.28	9.96	85.74	89.23	10
15	85.57	58.20	86.14	1.72	6.29	3.17	0.20	1.63	...	...	0.10	96.75	0.87	10.89	10.54	86.20	88.30	8
37	85.4	71.87	86.3	2.4	1.60	2.64	0.04	0.34	...	...	0.08	96.84	0.62	11.49	11.12	90.22	92.67	8
38	81.5	63.26	81.6	2.1	3.12	4.29	0.13	1.09	0.07	0.03	0.10	97.08	0.87	10.66	10.35	84.21	86.94	6
24	85.3	64.23	86.1	2.6¶	2.03	2.48	0.05	0.44	...	...	0.05	96.82	0.80	10.47	10.14	88.39	90.87	9
3	85.78	53.80	86.34	1.81¶	1.91	2.93	0.06	0.45	...	...	0.09	96.79	0.78	11.17	10.81	86.62	90.23	6
31	85.31	65.48	85.52	1.89	1.61	2.35	0.04	0.35	0.06	0.01	0.07	96.58	0.89	9.70	9.37	85.82	88.94	5§
26	86.70	59.70	86.40	0.15	1.88	4.17	0.08	0.57	0.13	0.08	0.21	96.45	...	11.62	11.21	81.70	85.31	5
9	83.66	65.04	83.70	1.90	2.77	2.31	0.06	0.49	...	...	0.06	96.79	0.79	11.48	11.12	85.09	88.01	5
32	85.55	60.25	85.21	1.16¶	3.29	3.39	0.11	0.93	...	...	0.06	96.40	1.05	10.72	10.33	86.38	89.80	5
40	85.12	55.33	85.05	1.79	2.53	3.24	0.08	0.68	...	...	0.10	96.56	0.94	10.91	10.54	87.01	90.68	4
23	81.0	54.00	81.6	1.6	3.46	2.95	0.10	0.90	...	...	0.09	96.3	1.24	9.99	9.63	84.65	87.17	4§
47	83.95	56.81	83.36	0.98	3.42	2.18	0.08	0.64	...	...	0.06	96.54	...	10.01	9.66	82.42	86.89	2
29	84.91	58.88	85.21	1.33	3.70	2.64	0.10	0.85	...	...	0.05	96.42	...	9.45	9.11	78.91	84.98	2
39	84.54	62.31	85.04	1.68	1.71	2.26	0.04	0.33	...	...	0.07	96.39	1.06	9.81	9.45	81.78	89.09	2
4	83.53	65.87	83.57	0.01	2.40	2.18	0.05	0.41	0.07	0.01	0.08	96.24	...	11.73	11.29	88.66	90.87	2
11	84.1	53.9	84.97	2.60	4.39	3.65	0.16	1.39	0.07	0.01	0.08	96.05	1.22	9.90	9.51	82.60	88.66	2
18	83.6	63.86	83.7	1.0	1.84	1.36	0.03	0.19	...	...	0.24	96.65	1.1	11.01	10.64	81.37	82.83	2
1923	....	63.26	85.65	1.38	2.31	2.22	0.05	0.40	...	...	0.087	96.90	0.83	11.69	11.33	88.77	91.28	..
1922	....	63.37	84.96	1.23	2.57	2.65	0.07	0.53	....	....	0.084	96.88	0.87	11.61	11.24	87.02	89.68	..
1921	....	62.09	83.90	1.13	1.66	2.58	0.04	0.33	....	....	0.074	96.75	0.92	11.62	11.24	85.86	88.03	..
1920	....	61.34	85.20	1.33	1.65	2.63	0.04	0.31	....	....	0.071	96.36	0.97	12.32	11.87	87.35	89.56	..
1919	....	62.42	85.70	1.41	1.34	2.32	0.03	0.22	....	....	0.076	96.34	0.96	12.59	12.13	88.57	90.96	..
1918	....	61.66	85.78	1.79	1.48	2.36	0.03	0.26	....	....	0.072	96.53	0.94	11.75	11.34	87.91	90.37	..
1917	....	62.28	86.36	1.48	1.52	2.28	0.03	0.25	....	....	0.063	96.87	0.87	12.45	12.06	87.93	90.58	..
1916	....	62.73	86.18	1.59	1.82	2.20	0.04	0.30	....	....	0.06	96.31	1.06	12.25	11.80	87.98	90.84	..
1915	....	61.64	86.59	1.84	1.81	1.89	0.03	0.25	....	....	0.07	96.40	0.98	12.52	12.07	87.65	91.03	..
1914	....	60.93	87.31	1.61	1.76	1.78	0.03	0.23	....	....	....	96.66	0.93	12.30	11.89	86.56	90.95	..

Factory No.	Final Molasses: Weight per 100 cane	F.M.: Sucrose per 100 cane	F.M.: Sucrose per 100 pol. of cane	F.M.: Sucrose per 100 pol. of juice	F.M.: Gravity solids	F.M.: Gravity purity	F.M.: True purity	Other Known Losses: Pol. per 100 cane	O.K.L.: Pol. per 100 pol. of cane	Undetermined Losses: Pol. per 100 cane	U.L.: Pol. per 100 pol. of cane	Factory No.	Factory
6	2.39	0.83	5.92	6.10	88.70	39.04	....	....	....	—0.11	—0.81	6	H. C. & S. Co.**
20	2.83	0.98	7.14	7.30	90.09	38.35	....	....	....	0.06	0.43	20	Oahu
5	3.19	1.01	8.15	8.39	89.78	35.30	....	....	....	0.01	0.10	5	Ewa††
17	3.12	1.14	8.73	8.98	91.99	39.77	....	....	....	0.09	0.68	17	Waialua††
10	2.84	0.91	6.65	6.79	89.26	36.00	....	....	....	0.06	0.40	10	Pioneer
21	2.43	0.85	6.36	6.51	87.87	40.07	43.69	....	....	—0.18	—1.36	21	Maui Agr.**
36	2.95	1.00	8.14	8.43	86.90	39.1	....	....	....	0.04	0.35	36	Olaa
16	2.87	0.92	6.47	6.62	87.63	36.62	40.08	....	....	0.02	0.17	16	Haw. Sug.
34	2.43	0.78	6.30	6.37	88.96	36.16	....	....	....	0.10	0.81	34	Onomea
13	4.33	1.54	11.48	11.88	89.63	39.74	....	0.04	0.31	...	...	13	Honolulu
7	2.52	0.77	6.15	6.22	85.55	35.58	....	....	....	0.06	0.51	7	Hakalau
25	2.84	0.99	7.23	7.50	90.16	38.68	42.81	....	....	0.23	1.70	25	Kekaha
27	2.89	0.94	7.62	7.80	93.16	34.80	....	....	....	0.02	0.17	27	Lihue
30	2.86	0.91	7.69	7.92	81.03	39.21	....	....	....	0.26	2.19	30	Haw. Agr.†‡
33	2.50	0.82	6.81	6.91	86.78	37.75	.....	....	....	0.03	0.22	33	Hilo
12	3.52	1.19	9.22	9.56	90.99	37.11	41.64	....	....	0.01	0.10	12	McBryde
2	2.91	0.95	7.29	7.47	84.72	38.5	....	....	....	0.01	0.08	2	Wailuku
14	2.92	1.00	8.34	8.56	91.44	37.55	....	....	....	0.28	2.34	14	Makee
41	2.91	1.04	8.27	8.53	90.48	39.41	45.16	....	....	0.11	0.84	41	Laupahoehoe
35	3.08	0.97	8.66	9.01	80.89	39.07	....	....	....	0.05	0.42	35	Honokaa
19	2.24	0.71	5.72	5.83	90.95	34.7	39.5	....	....	0.12	1.00	19	Pepeekeo
43	3.09	0.97	8.36	8.70	94.72	33.16	....	....	....	0.13	1.08	43	Kahuku††
15	2.37	0.90	7.39	7.57	88.76	42.91	....	....	....	0.29	2.40	15	Hamakua
37	2.45	0.79	6.39	6.56	90.51	35.6	....	....	....	0.05	0.40	37	Honomu
38	3.72	1.22	9.92	10.24	84.80	38.63	....	....	....	0.20	1.64	38	Koloa
24	2.76	0.87	7.61	7.83	86.20	36.68	....	....	....	0.10	0.83	24	Paauhau
3	2.43	0.81	6.49	6.76	84.13	39.65	....	....	....	0.30	2.44	3	Waiakea
31	2.81	0.94	8.64	8.95	82.19	40.83	....	....	....	0.18	1.69	31	Hutchinson†‡
26	3.99	1.47	10.75	11.22	88.70	41.7	....	....	....	0.38	2.75	26	Hawi
9	...	....	....	....	85.45	41.05	46.03	....	....	1.45	11.10	9	Waianae
32	2.71	0.96	8.03	8.35	88.03	40.29	....	....	....	0.10	0.85	32	Kaiwiki††
40	2.74	0.97	7.98	8.32	92.33	38.20	....	....	....	0.03	0.28	40	Kohala
23	2.92	0.98	8.65	8.91	85.29	39.5	....	....	....	0.33	2.91	23	Kilauea††
47	3.34	1.23	10.50	11.07	89.75	41.00	....	....	....	0.15	1.30	47	Kaeleku
29	...	....	....	....	85.4	43.8	48.8	....	....	1.51	13.10	29	Halawa
39	...	....	....	....	86.60	41.02	....	....	....	1.12	9.68	39	Niulii
4	...	....	....	....	....	....	....	....	....	1.08	8.49	4	Waimea
11	2.79	1.04	9.05	9.71	89.2	41.91	....	....	....	0.01	0.12	11	Union Mill††
18	4.87	1.62	12.37	12.59	82.63	40.17	....	....	....	0.56	4.31	18	Olowalu
1923	2.89	0.97	7.58	7.79	88.53	37.90	....	....	....	0.08	0.48	1923	
1922	3.11	1.06	8.16	8.41	87.91	38.75	....	....	....	0.21	1.27	1922	
1921	3.63	1.22	9.27	9.51	87.12	38.53	....	....	....	0.28	1.97	1921	
1920	3.24	1.10	8.03	8.24	87.42	38.75	....	....	....	....	....	1920	
1919	3.02	1.00	7.24	7.42	87.34	37.95	....	....	....	....	....	1919	
1918	3.04	1.04	7.96	8.17	87.32	39.07	....	....	....	....	....	1918	
1917	3.07	1.07	7.68	7.89	86.68	40.03	....	....	....	....	....	1917	
1916	2.90	0.98	7.41	7.64	87.63	39.25	....	....	....	....	....	1916	
1915	2.81	0.97	6.98	7.22	87.36	39.69	....	....	....	....	....	1915	
1914	2.80	0.99	7.12	7.43	87.87	40.40	....	....	....	....	....	1914	

* Sucrose.
† Refined sugar.
‡ For one mill only.
¶ Probably influenced by low grade sugar in syrup.
§ 1923 crop unfinished.
** Peters process.
†† Balance of 1922 crop included.